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DISASTERS

25 TRAGIC MOMENTS THAT SHOOK THE WORLD

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FEATURING

- Deepwater Horizon ⚠
- San Francisco Earthquake ⚠
- Tenerife Airport ⚠
- The Black Death ⚠
- Hillsborough ⚠

ALSO INSIDE

VOLCANIC ERUPTIONS

DEADLY EARTHQUAKES

CATASTROPHIC CRASHES

Earthquakes. Tsunamis. Volcanic eruptions. Pandemics. Disaster and devastation has plagued humankind and threatened our survival from the dawn of our existence. Technological advancements have led to further tragedy: aviation incidents, oils spills and nuclear meltdowns that we fight to contain.

Ever since the media began to broadcast events live and globally, we have experienced an almost unending stream of reportage delivered right into our homes. But despite this, we still sometimes struggle to comprehend many aspects of a disaster. How do we measure the scale of a cataclysm? How does a person respond to such a tragedy? And what happens once the damage is done and the wave pulls back?

The Book of Disasters takes an in-depth look at some of the most devastating events throughout history and investigates these questions. From the destruction of Pompeii and the desolation left in the wake of the Black Death, to the explosion of the Space Shuttle Challenger and the plane crash in the Andes that pushed human endurance its limits, a whole host of modern and historic events are covered here. Read the stories of eyewitnesses and interviews with experts in an effort to understand the disasters that altered the course of human history.

DISASTERS

Imagine Publishing Ltd
Richmond House
33 Richmond Hill
Bournemouth
Dorset BH2 6EZ
☎ +44 (0) 1202 586200
Website: www.imagine-publishing.co.uk

Publishing Director
Aaron Asadi

Head of Design
Ross Andrews

Editor in Chief
Jon White

Production Editor
Hannah Westlake

Senior Art Editor
Greg Whitaker

Designer
Phil Martin

Printed by
William Gibbons, 26 Planetary Road, Willenhall, West Midlands, WV13 3XT

Distributed in the UK, Eire & the Rest of the World by
Marketforce, 5 Churchill Place, Canary Wharf, London, E14 5HU
Tel 0203 787 9060 www.marketforce.co.uk

Distributed in Australia by
Gordon & Gotch Australia Pty Ltd, 26 Rodborough Road, Frenchs Forest, NSW, 2086 Australia
Tel: +61 2 9972 8800, www.gordongotch.com.au

ISBN 9781785463907

Part of the
ALL ABOUT HISTORY
bookazine series

IMAGINE PUBLISHING

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DISASTERS THROUGH HISTORY

From earthquakes to epidemics, crashes to collapses – as long as humans have existed on this earth, disasters have threatened death and destruction

27 CE

FIDENAE AMPHITHEATRE COLLAPSE

Rome ■ 27 CE

79 CE

POMPEII

Pompeii, Roman Empire ■ 79 CE

In late summer 79 CE, the residents of Pompeii went about their lives as usual, unaware that, at 1pm, the top of the mountain would explode in a catastrophic eruption unlike any other. Mount Vesuvius spewed a deadly cloud of volcanic gas, stone and ash to a height of 33 kilometres. 1.5 million tons of molten rock and pulverised pumice was ejected every second.

Hours later hot gas and rock began to speed down the mountain. The flows destroyed anything in their path and, although they bypassed Pompeii, their sheer heat would kill anybody within ten kilometres. By the evening of the second day the eruption was over, but ash continued to drift onto Pompeii, covering it with a layer four to six metres thick.

165 CE

ANTONINE PLAGUE

Roman Empire ■ 165 CE

BLACK DEATH

Britain ■ 1348-1350

The Black Death is thought to have originated in Central Asia from where it travelled along the Silk Road and around Europe on merchant ships. It was named after the black buboes in the groin, neck and armpits that were the first symptoms. A fever and vomiting blood followed, death arrived within a few days. The Black Death reached Britain in 1348, first seen around Bristol. People flocked to superstitious methods like flagellation, hoping to appease God. The real problem was that unhygienic medieval towns were a perfect breeding ground for the disease.

The Black Death is estimated to have killed half of Britain's population; up to 60 per cent in London. But the hard times were not over. Harvests failed and food prices increased. The disease even returned periodically for the next few centuries – ending with the Great Plague of 1665.

THE MARY ROSE CAPSIZES

UK ■ 1545

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GREAT FIRE OF LONDON

UK ■ 1666

Turn to page 88

MOSCOW PLAGUE & RIOT

Moscow ■ 1771

1348 | 1545 | 1666 | 1755 | 1771 | 1775

LISBON EARTHQUAKE

Lisbon, Portugal ■ 1755

When an earthquake struck the Portuguese capital on 1st November 1755, the devastation was almost absolute. The buildings that survived the quake, estimated at magnitude nine on the Richter scale, were then struck by a tsunami and city-wide fire. The death toll was undoubtedly high, although such was the destruction that estimates widely vary from 10,000 to 100,000 people. Yet Lisbon was quickly rebuilt and designed to resist subsequent earthquakes; models were used to test the strength of building designs, the effects of an earthquake on them were simulated by marching troops nearby. It was the birth of modern seismology.

NORTH AMERICAN SMALLPOX EPIDEMIC

USA, Canada and Mexico ■ 1775-1782

Smallpox was not a new disease in America in 1775. It had existed as far back as Columbus' first voyage to the New World, but it was during the American Revolution that the unhygienic conditions in army camps sparked a smallpox epidemic which spread across the continent. During the siege of Boston, both American and British troops were ravaged by the illness. Native Americans were particularly at risk; populations on the western seaboard reduced by almost a third.

Washington knew smallpox could devastate the colonists' chances of victory. He quarantined infected soldiers, refused to allow civilians near his troops and retreated from infected areas. He also ensured his soldiers were inoculated against the disease at a time when inoculation was controversial and people were aghast at the idea of deliberately infecting themselves. However, his actions worked and the disease was eradicated from his army. Not only did Washington help win US independence, he also kick-started public health initiatives.

GREAT FAMINE

Ireland ■ 1845-1852

Potato blight decimated potato crops throughout Europe, but its effect on Ireland was catastrophic as it was particularly dependent on them. When the crops failed in 1845, mass starvation began. Charitable donations and initiatives eased Irish suffering a little, but the reaction of the British government was negligible, even allowing Irish landlords to export food. Around 1 million people died and a million more emigrated, leading to a fall in the Irish population of 20 to 25 per cent and permanently souring Irish-British relations.

CHURCH OF THE COMPANY FIRE

Santiago, Chile ■ 1863

Preparing for Mass at the Church of the Company of Jesus in Santiago on 8th December 1863, Father Ugarte set up thousands of candles and oil lamps, draped muslin and gauze curtains from the ceiling and scattered ribbons and paper flowers, hoping to impress the prominent members of Santiago society.

The church was packed with around 3,000 people to celebrate the Feast of the Immaculate Conceptioyn. As Mass was about to begin, at the altar, oil lamps positioned behind a painting were lit, the flames ignited the painting. The fire quickly spread. Once the roof started to burn, the oil lamps hanging from it dropped to the crowd beneath, turning the floor of the church into a lake of fire. The church burned to the ground in just over an hour and some 2,500 died.

1845 1855 1863 1912

THE THIRD PANDEMIC

China & India ■ 1855

TITANIC

North Atlantic ■ 1912

Titanic was feted as the biggest, fastest and most luxurious ocean liner built when it was launched in 1912, but all went wrong on the fifth day of its maiden voyage to New York. When the captain ignored ice warnings in the hope that *Titanic* might arrive ahead of schedule, the ship scraped along an iceberg, puncturing the hull with a series of holes. Too many watertight compartments were flooded. Three hours later, *Titanic* lay at the bottom of the Atlantic Ocean. More than 1,500 lives were lost, partly because the ship did not carry enough lifeboats for all on board.

HALIFAX EXPLOSION

Halifax, Canada ■ 1917

The collision between two ships near Halifax on 6th December 1917 occurred at a measly speed of just 1 knot (1.5 mph), but it started a small fire on the *Mont-Blanc*, a French cargo ship laden with explosives. As the fire got out of control, the captain frantically gave the order to abandon ship. 20 minutes after the collision, *Mont-Blanc* exploded. It was the largest man-made explosion prior to nuclear weapons, releasing the equivalent energy of 2.9 kilotons of TNT.

Nearly all buildings with two kilometres were destroyed. 2,000 people died and 9,000 were injured but, amazingly, the captain's decision to abandon *Mont-Blanc* meant only one of his 41 men died.

TAY BRIDGE COLLAPSE

Dundee, Britain ■ 1879

The Tay Rail Bridge had been in use for eighteen months before tragedy hit on 28th December 1879. The bridge collapsed during a storm as a train was passing over it, killing all aboard. There were believed to be 75 victims, but while the train was recovered, not all bodies were found.

The Tay Bridge had been designed by Thomas Bouch, an experienced engineer who'd been knighted for his accomplishments. His design used lattice girders supported by piers with iron columns and cross-bracing. However, the piers were narrower and their cross-bracing was less extensive than on his previous bridges. Bouch believed it wasn't necessary to take into account the force that the wind would put on the bridge and opted for a cheaper design. He also knew that construction workers were reusing girders which had been dropped in the estuary and that there were imperfections in the materials and their maintenance. Bouch died within a year of the disaster, his health and reputation in tatters.

SAN FRANCISCO EARTHQUAKE

USA ■ 1906

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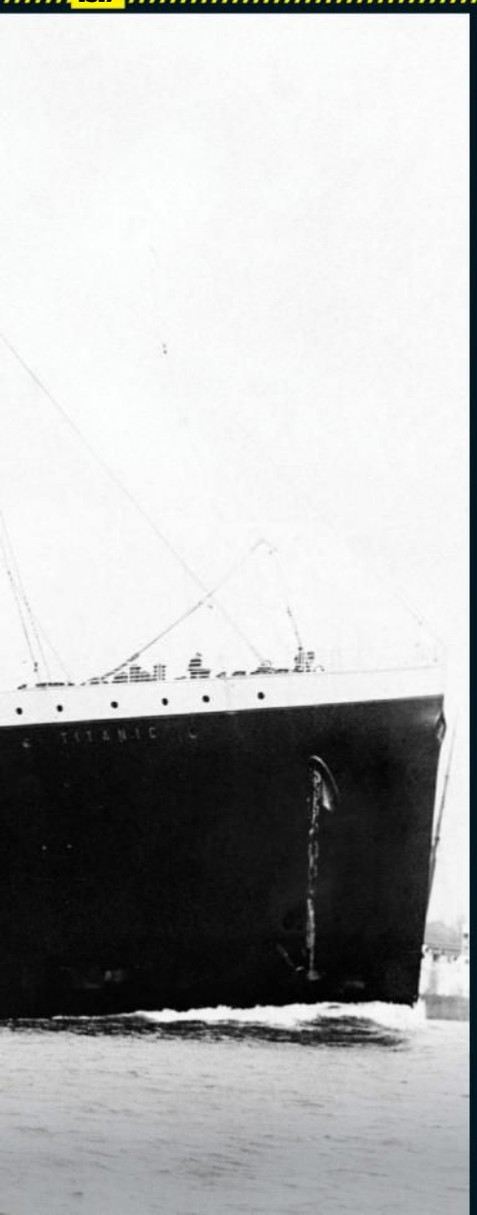
1917 | 1879 | 1883 | 1906 | 1918



KRAKATOA EXPLODES

Indonesia ■ 1883

SPANISH FLU

Worldwide ■ 1918-1920

At the end of the First World War in 1918, many soldiers would not return, struck down by influenza. The Spanish flu pandemic was unusually deadly, killing healthy young adults as opposed to the young, elderly or sick. Modern research suggests that it killed through an overreaction of the body's own immune system, so those with a stronger immune system were actually more at risk, and troop movements likely aided its spread. Countries at war censored reports of deaths in their own countries while reporting the rapid spread of influenza in neutral Spain – hence the nickname. Deaths were reported around the globe, including isolated islands – 22 per cent of the population of German Samoa perished. It infected 500 million people across the world and killed 50 to 100 million (3 to 5 per cent of the world's population).

CHINA FLOODS

China ■ 1931

After two years of drought, by 1931 the people of China were praying for rain. A few months later, they were desperate for the rain to stop. Far too much water was released when the thaw of winter snows combined with months of heavy rainfall and the Yellow, Yantze and Huai rivers burst their banks, flooding large areas. Many drowned, including 200,000 who were killed in their sleep when water washed away the embankments around Gaoyou Lake. The floods soon reached the capital, Nanjing, where many succumbed to waterborne diseases. In total as many as four million may have died as a result of the floods.

HINDENBURG CATCHES FIRE

USA ■ 1937

Turn to page 164

1931 1937 1952 1955

GREAT SMOG

London, Britain ■ 1952

Thick smog was nothing new to Londoners in 1952. They were used to poor air quality, but the pea-souper which lasted for five days in early December was worse than anything seen before. Cold weather and windless conditions allowed a belt of yellow-black smog to collect over the city. Visibility was reduced to a few metres and transport ground to a halt, even ambulances stopped driving. The smog seeped indoors, so that theatregoers could not see the stage. Medical reports estimated that 4,000 people had died prematurely as a result, while 100,000 more became ill – though most had pre-existing respiratory conditions. Recent research suggests that up to 12,000 may have died. It caused a rethinking of the impact of air pollution on health and new regulations were implemented.

LE MANS DISASTER

Le Mans, France ■ 1955

Tragedy struck the 24 Hours of Le Mans motor race in June 1955 when Pierre Levegh collided with a competitor and his car flew upwards into the spectator enclosure. Levegh died instantly and pieces of his car flew into the crowd, decapitating spectators: 83 people died and 120 more were injured. The race continued, partly to stop departing audience members from blocking the roads for ambulances. Levegh's Daimler-Benz team withdrew, as did Mercedes, but Jaguar continued and the race was won by Mike Hawthorn – the driver who many saw as the cause of Levege's accident.

DRAINING OF THE ARAL SEA

Kazakhstan and Uzbekistan ■ 1960-present

In 1960, the Aral Sea was the fourth largest lake at 68,000 square kilometres. By 2007, it had shrunk to under 7,000. Soviet engineering projects were to blame, diverting the rivers that fed the Sea to irrigate the surrounding desert for cotton production.

Now the Aral Sea has split into two smaller lakes and salinity levels have rocketed. Ecosystems have been destroyed and dust storms are common. The fishing industry has all but disappeared. The area is heavily polluted, partly by the overuse of fertilisers and pesticides as local farmers try to grow what they can, partly because toxic chemicals – the result of Soviet weapons testing – remain locked in the soil.

ANDES FLIGHT DISASTER
Chile ■ 1972
Turn to page 100

TORREY CANYON SHIPWRECK AND OIL SPILL
UK ■ 1967

1960 | 1963 | 1966 | 1967 | 1971 | 1972

ABERFAN LANDSLIDE
Wales ■ 1966

VAJONT DAM LANDSLIDE AND MEGATSUNAMI
Italy ■ 1963

SOYUZ 11 DECOMPRESSION

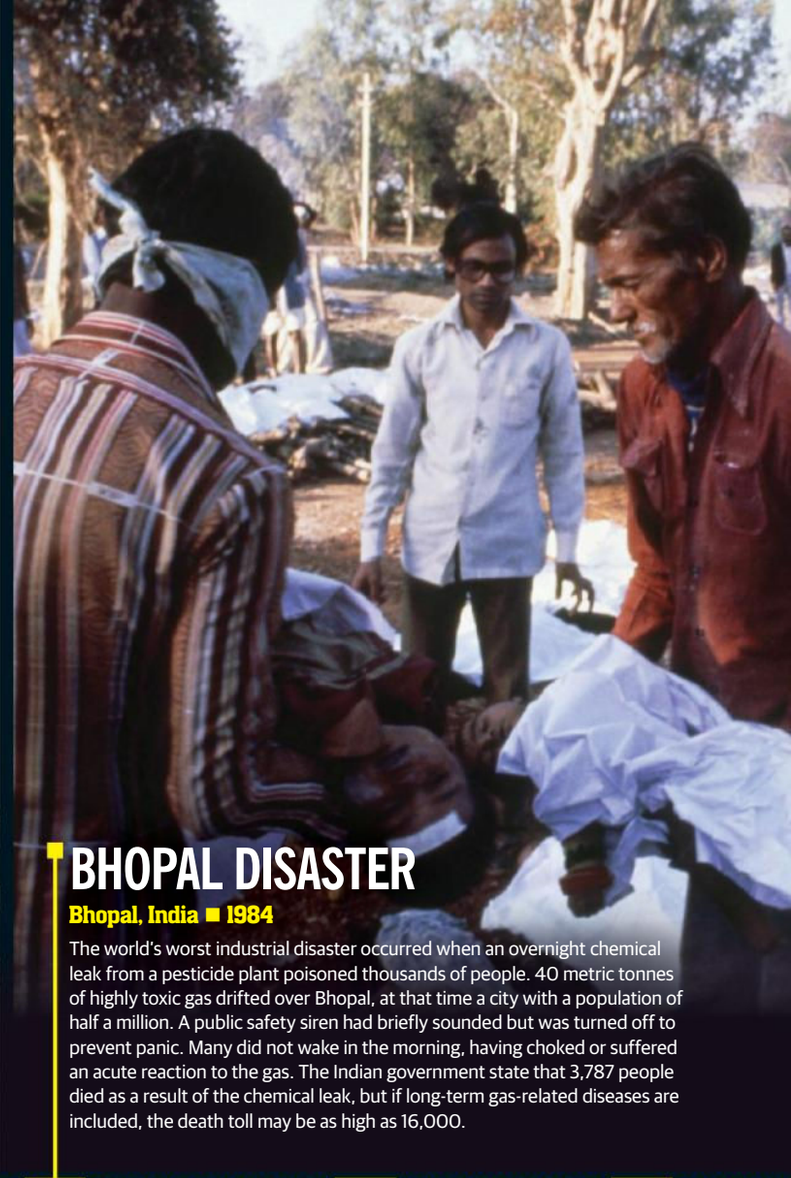
USSR ■ 1971

The three Soviet cosmonauts of Soyuz 11 were returning after a record-breaking 23 days in orbit, being the first to live in a space station, Salyut 1. The capsule made a perfect parachuted touch-down on the Kazakh Steppe, but when the rescue crew opened the hatch, what they saw horrified them. The three crew members – Georgy Dobrovolsky, Vladislav Volkov and Viktor Patsayev – were dead. Blood poured from their noses and ears. A ventilation valve failed at the start of the descent, 168 kilometres above Earth, rapidly depressurising the capsule, leaving them in an air vacuum. The cosmonauts likely died within a minute and are the only people to have died in space.

TENERIFE AIRPORT DISASTER

Los Rodeos Airport, Tenerife ■ 1977

KLM flight 4805 and Pan Am flight 1736 were en route to Gran Canaria when a bomb in that airport diverted the two Boeing 747s to Los Rodeos in Tenerife. Three other large planes were also diverted to the small airport. Planes were forced to park on the taxiways, so they had to taxi up and down the single runway to get in position for take-off. The KLM plane taxied to the end of the runway for take-off, and the Pan Am flight followed it up the runway, looking for the turning it should take to leave the runway clear. Thick fog meant the pilots, and even the air traffic controller, couldn't see a thing. What followed next was a miscommunication. The KLM pilot thought that he was cleared for take-off and accelerated down the runway. As the pilots of caught sight of each other, the Pan Am swerved to the left, the KLM pilot tried to take off early. The KLM's nose cleared the Pan Am but the landing gear and fuselage clipped it, ripping the Pan Am apart. The KLM plane dropped back and its fuel ignited, starting a huge fire. Everybody on the KLM plane was killed, 61 survived on the Pan Am; at 583 deaths, it was the worst aviation disaster in history.



BHOPAL DISASTER

Bhopal, India ■ 1984

The world's worst industrial disaster occurred when an overnight chemical leak from a pesticide plant poisoned thousands of people. 40 metric tonnes of highly toxic gas drifted over Bhopal, at that time a city with a population of half a million. A public safety siren had briefly sounded but was turned off to prevent panic. Many did not wake in the morning, having choked or suffered an acute reaction to the gas. The Indian government state that 3,787 people died as a result of the chemical leak, but if long-term gas-related diseases are included, the death toll may be as high as 16,000.

1977 1978 1980 1984 1986 1986

AMOCO CADIZ SHIPWRECK AND OIL SPILL

France ■ 1978

MOUNT ST HELENS ERUPTS

USA ■ 1980

A 5.1 magnitude earthquake on 18th May 1980 was the sign of more upheaval to come. The mountain blew sideways, sending a plume of ash into the sky and causing an avalanche. Huge swathes of land were destroyed and 57 people lost their lives.

CHERNOBYL

Pripyat, USSR ■ 1986

When a power surge occurred during a systems test at Chernobyl nuclear power plant, catastrophe ensued. A series of explosions sent a plume of highly radioactive fallout – equivalent to 400 Hiroshima bombs – into the atmosphere. Approximately 60 per cent of the fallout landed in Ukraine and Belarus, but winds pushed some of it as far as Sweden. The nearby city of Pripyat was not evacuated until 24 hours later; the residents never returned. The official Soviet death toll was 31, primarily power plant staff or emergency workers with acute radiation syndrome. It's harder to measure the effect on the millions of people exposed to radiation.

SPACE SHUTTLE CHALLENGER

USA ■ 1986

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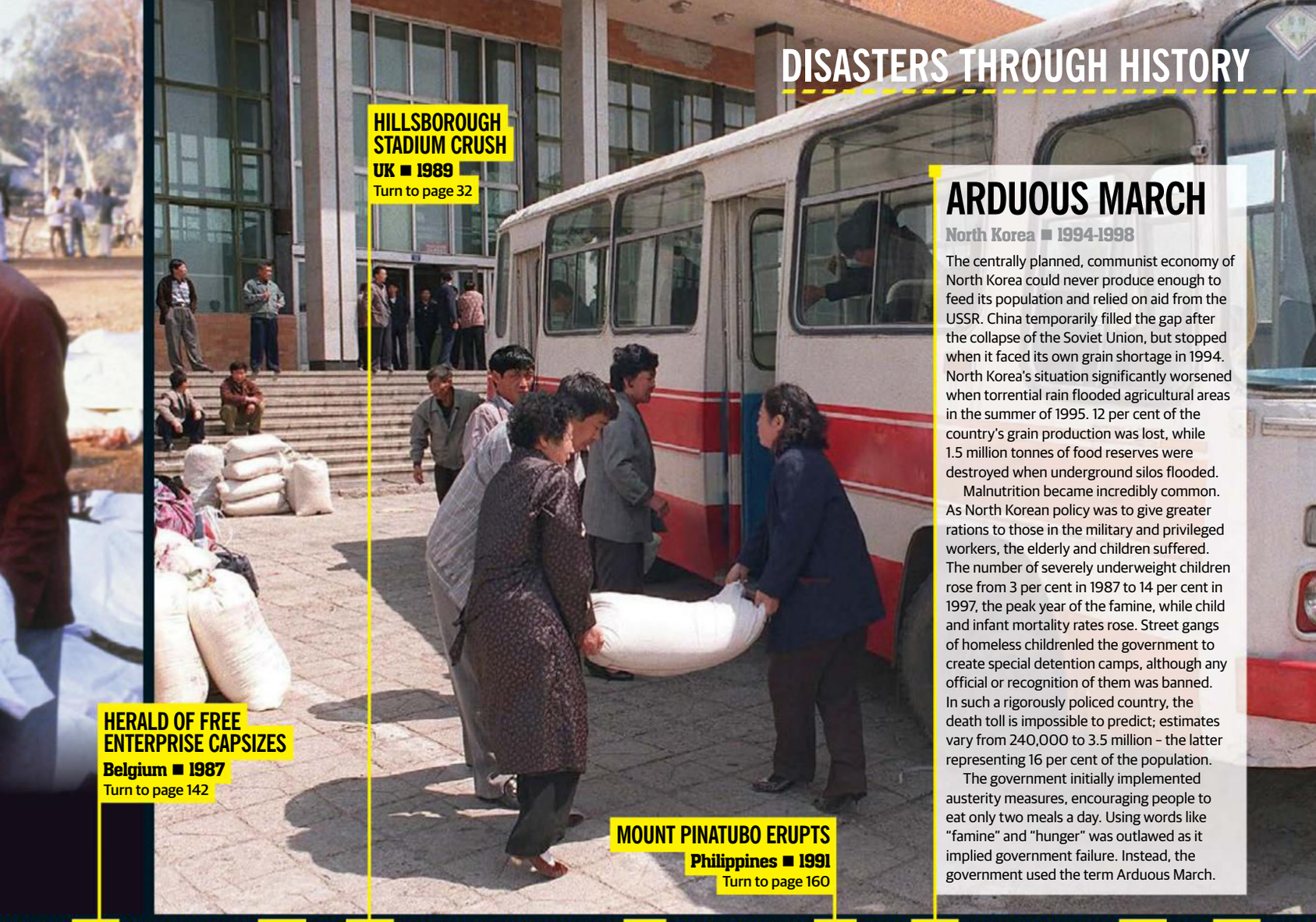

HILLSBOROUGH STADIUM CRUSH
UK ■ 1989
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HERALD OF FREE ENTERPRISE CAPSIZES
Belgium ■ 1987
Turn to page 142

MOUNT PINATUBO ERUPTS
Philippines ■ 1991
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ARDUOUS MARCH

North Korea ■ 1994-1998

The centrally planned, communist economy of North Korea could never produce enough to feed its population and relied on aid from the USSR. China temporarily filled the gap after the collapse of the Soviet Union, but stopped when it faced its own grain shortage in 1994. North Korea's situation significantly worsened when torrential rain flooded agricultural areas in the summer of 1995. 12 per cent of the country's grain production was lost, while 1.5 million tonnes of food reserves were destroyed when underground silos flooded.

Malnutrition became incredibly common. As North Korean policy was to give greater rations to those in the military and privileged workers, the elderly and children suffered. The number of severely underweight children rose from 3 per cent in 1987 to 14 per cent in 1997, the peak year of the famine, while child and infant mortality rates rose. Street gangs of homeless childrenled the government to create special detention camps, although any official or recognition of them was banned. In such a rigorously policed country, the death toll is impossible to predict; estimates vary from 240,000 to 3.5 million – the latter representing 16 per cent of the population.

The government initially implemented austerity measures, encouraging people to eat only two meals a day. Using words like "famine" and "hunger" was outlawed as it implied government failure. Instead, the government used the term Arduous March.

1987 1988 1989 1991 1991 1994 1998 1999

PIPER ALPHA OIL PLATFORM
North Sea ■ 1988

ESCHEDE DERAILMENT
Germany ■ 1998
Turn to page 52

MONT BLANC TUNNEL FIRE
European Alps ■ 1999

KUWAITI OIL FIRES

Kuwait ■ 1991

When Saddam Hussein's Iraqi forces retreated after a failed invasion of Kuwait, they lit more than 600 oil wells. Punishment for their overproduction of oil was part of the reason, as was the hope that the intense smoke plumes would inhibit air strikes against the Iraqi army. They also released oil into low-lying areas to defend against ground attacks, as huge oil-burning fire trenches.

The first wells were set ablaze in January 1991 and there were no efforts to bring them under control until April. In November the last well was extinguished; over eleven months one billion barrels of oil are thought to have burned. Countries across the Arabian Peninsula experienced darkened skies and carbon soot fallout. More environmental damage was actually caused by the oil that was spilled without being burned, contaminating 40 million tons of sand and earth.

CONCORDE CRASH

France ■ 2000

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SPACE SHUTTLE COLUMBIA

USA ■ 2003

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THE STATION NIGHTCLUB FIRE

USA ■ 2003

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EUROPEAN HEATWAVE

Europe ■ 2003

The summer of 2003 saw a heatwave which was so extreme that it claimed up to 70,000 lives across Europe. Record temperatures were set in England, Scotland, Germany and Switzerland, but it was France that was worst affected. The heatwave occurred during August, traditionally when the French take their holidays, so many elderly people did not receive adequate care. It showed that governments needed to have policies to deal with extreme heat and helped improve public awareness of the dangers posed by it.

HURRICANE KATRINA

USA ■ 2005

Causing $108 billion of damage, Hurricane Katrina was the costliest storm in history. When it passed over the southern United States, it caused mass flooding. Worst hit was New Orleans – the city's flood defences were overwhelmed and 80 per cent of the city was underwater, lasting for weeks. The economic fallout was vast: 30 oil platforms were damaged, gas production fell by 82 per cent, the forestry industry lost land worth $5 billion. The human cost was also high – around 1,440 people died in a disaster area the same size as the UK.

2000 2001 2002 2003 2003 2003 2004 2004 2005

SARS CRISIS

Worldwide ■ 2002-2003

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QUEENS PLANE CRASH

USA ■ 2001

QUEEN OF THE SEA RAIL DISASTER

Peraliya, Sri Lanka ■ 2004

Among the victims of the Boxing Day Tsunami of 2004 were passengers on board the train the *Queen of the Sea*. It carried 1,500 fee-paying passengers and even more unpaid passengers. Only 150 survived, making it the deadliest rail disaster. The first of the large waves struck as the train passed the village of Peraliya, bringing the train to a halt. Passengers climbed on top of the carriages, while others stood on the landward side to avoid the water. Then, a much larger wave – two or three metres above the train – picked it up from the track and carried it 100 metres inland. Those inside the carriages or on top drowned, those sheltering behind were crushed. Only 900 bodies were recovered.

INDIAN OCEAN EARTHQUAKE AND TSUNAMI

Indian Ocean ■ 2004

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HAITI EARTHQUAKE

Haiti ■ 2010

The 2010 earthquake hit Haiti, as one of the poorest countries in the world, extremely hard. A lack of building regulations meant that many buildings had no chance of withstanding the magnitude 7 earthquake, while high levels of poverty meant that many of the destroyed areas were overcrowded. 250,000 houses collapsed or needed to be demolished, and even sections of the President's National Palace were severely damaged. Experts estimated that 160,000 were killed with many more left injured or homeless.

A major cause of the high casualty figures was the wrecked infrastructure, which hampered rescue and relief efforts. Every hospital in the capital was damaged, including three which completely collapsed. Morgue facilities were overwhelmed and 1,000 bodies were left to decompose outside before they could be buried in mass graves. Disease inevitably spread, with over 6 per cent of Haitians contracting cholera over the next three years.

DEEPWATER HORIZON
Gulf of Mexico ■ 2010
Turn to page 114

CHILEAN MINING DISASTER
Chile ■ 2010
Turn to page 154

SANTIAGO DE COMPOSTELA DERAILMENT
Spain ■ 2013

2010 | 2010 | 2010 | 2011 | 2011 | 2013 | 2013

EAST AFRICA DROUGHT

East Africa ■ 2011-2012

Drought and food shortages are an ever-present risk in the East African countries of Djibouti, Ethiopia, Kenya and Somalia. Rainfall levels were 70 per cent lower in 2011, leading to a poor harvest which pushed up food prices, while the prolonged heat caused the deaths of up to half of all livestock. 10 million people in the Horn of Africa saw food levels drop, with acute malnutrition affecting 37 per cent of children in parts of Kenya. Refugees fled to aid camps in Ethiopia and Kenya which were quickly overwhelmed. The Kenyan camps reached a population of 440,000 despite a capacity of 90,000. Cholera, malaria and measles outbreaks combined with malnutrition to increase mortality rates. Up to 250,000 died from starvation or disease.

TOHOKU EARTHQUAKE, TSUNAMI, AND FUKUSHIMA MELTDOWN
Japan ■ 2011
Turn to page 108

TYPHOON HAIYAN

Philippines ■ 2013

The Philippines had already been rocked by a magnitude 7.2 earthquake on 15 October 2013 when, three weeks later, Typhoon Haiyan hit. It was the strongest tropical cyclone recorded with wind speeds up to 195mph, but the real danger were storm surges. Six-metre waves occurred, flooding coastal settlements and washing away buildings. One particular surge reached the second story of the Tacloban Airport terminal building and 90 per cent of Tacloban City was thought to be destroyed. 281.9 mm of rainfall was recorded in under 12 hours. Power blackouts, landslides, tree falls and flash floods disrupted rescue teams. Once casualties were dealt with, relief efforts fought to stop chronic disease and help the 1.9 million homeless. In total 6,340 people died.

INDIAN OCEAN TSUNAMI

The ocean floor burst apart, releasing the monster tsunami across the sea to have its fill on the Boxing Day beaches

The sun glinted high and jubilant against the bright blue sky. It seemed oblivious that the azure sea below would soon obliterate nearly everything in its path. This is the story of Indian Ocean tsunami disaster and how the determination of many, many people reached out to save lives and make sure that a natural disaster of this scale never, ever happens again.

Sumatra is a holiday region. Whether you went there in high summer or at Christmas, you'd be met with honeyed beaches covered in warm, welcoming sand, dinky traditional fishing boats and nonchalant palm trees lilting in the breeze as far as the eye can see. Friendly locals chat happily with holiday makers and ex-patriots from other nations, all enjoying the healthy glow a paradise bestows.

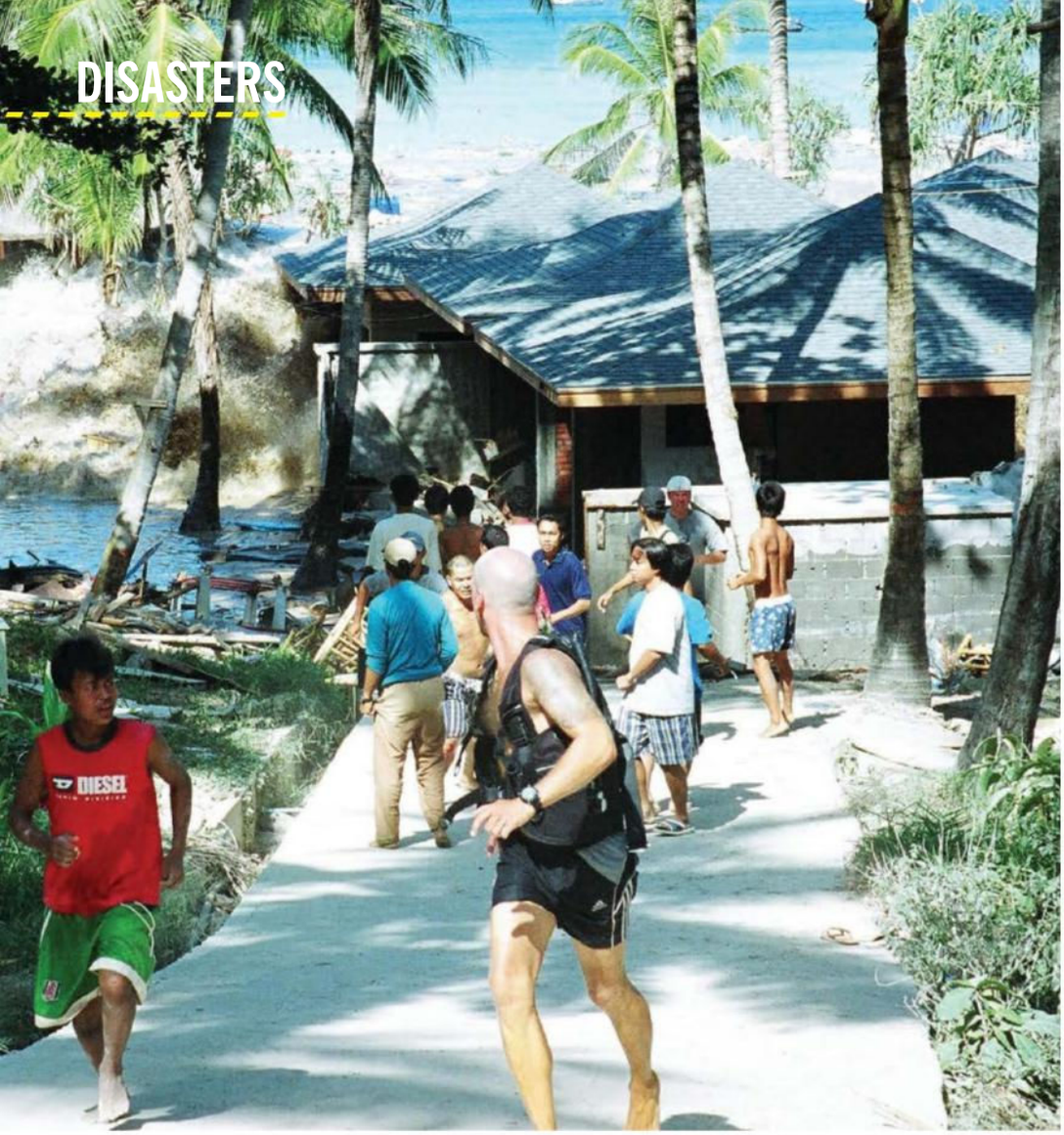
They didn't know about the invisible giant that was steadily moving towards them. Over 155 miles off the coast of Sunda Trench, Sumatra, something large and incredibly powerful was stirring. It always moved its massive, heavy body sleepily under the waves, but now it had been properly disturbed. It was a tectonic plate above the earth's core. Struggling for room in the dark depths, it ground against its neighbour, forcing it down; a process known as subduction. Finally one of the plate pair snapped upward, no longer able to hold the strain. It caused a massive flow of energy towards Sri Lanka: an earthquake. It was recorded by a seismograph in California, but it would be long hours before the results of this quake were analysed. In that time, a surge of water with a bulk head and a powerful body began plowing through the natural ocean.

The monster began its gradual trek up to the beaches. It was early morning at Sumatra but the streets were busy with tourists and locals. In the distance was the beach. People were already there, sunbathing, when the first wave came up. There is an unfortunate phenomenon associated with tsunamis. When they are due to hit, water actually withdraws from the rest of the beach first. People had, therefore, come to the beach

IN BRIEF

- **Death toll: 225,000+**
- **Indian Ocean**
- **26th December 2004**

The tsunami killed at least 225,000 people with its momentous magnitude of 9.2. The little existing video footage that there is shows its scale and instantaneous devastation.



“Experts noted that the power of the water alone was roughly the weight of a car”

Passersby are captured mid-motion as the hellish wave appears. Tourists often didn't know to run

walked further into the surf than usual. Standing in their swimming trunks and bikinis, they would, perhaps hold their arms out to feel the sea air on their skin, wiggling their toes in the damp sand as it shifted gently to accommodate their weight. They would see the wave travelling towards them and may have held their faces forward slightly, laughing to meet it. The wave's whisper would increase to a low rumble, the voice of a thousand jostling droplets, while the beach folks clenched the muscles in their arms, pursed their lips for the playfully salty coolness, squared their feet and dug their heels in...

In one small section of the limited witness footage that exists of the tsunami in progress, there is the longshot of a beach. A man is standing calmly on it as the wave approaches. The wave smashes over him and he disappears completely. The voiceover reminds you that you have just witnessed another human being's death on camera.

That man would not have realised what was happening until it was far too late. He may have noticed that the wave seemed more powerful than usual and might have assumed he would be knocked off balance, but would have thought that he could simply pick himself up again, shakily brushing the sand and stray shingle from his shorts and hair. Instead, the wave picked him up along with the other beach bric-a-brac it found in its path as it made its way up the shoreline.

By the time it had moved up the beach, the wave's force was catastrophic. Experts noted that the power of the water alone was roughly that of the weight of a car. Within that water was everything that the wave had picked up along the way – anything from umbrellas to cars to bits of masonry. Indeed, the wave wafted against the Banda Aceh Cement Works, a wall three times the height of a man and several feet wide. It was simply broken in two and tossed to the ground. A person would be picked up, buffeted underneath the floating debris and pinned there, sustaining horrific injuries from the brute force and flying edges before drowning.

The monster is still largely unknown to us, with the science of seismology and tsunami prediction still relatively new. It's one of the reasons why so many died; the experts simply did not know how or where the beast would move as it roared across the ocean. They also had no way to instantly communicate the information when they began to understand. Hence, 15 minutes after that first earthquake, the exposed coast of Sumatra was the first to be hit, the casualties there making up around three quarters of the total victim count. The Andaman and Nicobar Islands were pulverised a mere 15 minutes later, southern Thailand 45 minutes after them, Sri Lanka two hours later and four hours later The Maldives. Luckily, loss of life was largely prevented in Africa as the pattern of the powerful foe had been detected and the

seismologists were able to pre-warn the continent, allowing vulnerable areas to be evacuated.

Perhaps the hardest thing to accept in retrospect is that the damage caused was predictable. It is fate, dependent on coastline. Kamala beach was smashed to smithereens, the wave aided by a sloping coastline that enabled the beast to slither up the shore on its belly, unchallenged by underwater cliffs that could have broken its stride. Other places were left largely untouched, out of the tide's sight.

For every photograph that you see where the tsunami's aftermath seems to be the relatively innocuous-looking splinters of wood that almost authenticate a desert island, holiday environment, remember that under those bits of indistinguishable fragments of modern life (houses) are hundreds of human corpses lying on the sand.

After the waves had their play, they went away. A coda gut punch peculiar to tsunamis is that rather than the waves simply retreating, they actually suck their debris back to the ocean bed with them, some of their victims vanishing forever into the depths. Those people who were too much for the mammoth's belly would be found washed ashore in the later days as bloated, fish-eaten corpses perhaps looking eerily peaceful from a distance in the dawn's new light.

The rescue attempts were hampered from the outset, but the people were determined to band together. Hospitals were destroyed and with the tsunami swatting the infrastructure, even the water system was contaminated in some places. This led to concerns about the spread of disease. In many places, the water had blocked the roads and wrecked the electricity pylons. In some areas, people waited in vain for help that it seemed just never came; many regions, paradises though they appeared, were isolated hamlets away from the main thrust of island life.

Refugee centres were set up in places such as the tiny capital, Port Blair, where relatives could visit

A building sits amid a street of splintered timber in what would have been downtown Sumatra

THE ISABELLA PEATFIELD MEMORIAL FUND

Kim and Tristan Peatfield established a charity in their daughter's name after she was taken by the flood waters. Little 'Bellie', as she was known, had fallen in love with Sri Lanka in the short time that she was on the island and loved to play with the children there. It was her first big holiday. A photograph of her shows a small girl, head tilted slightly as she squints in the beautiful sunshine in her summer dress.

To date, the charity works to sponsor children to get a good education and escape poverty. It helps a number of orphanages by providing money to cover their maintenance costs, has supplied a library, funded an annual Christmas party in Isabella's name and provide plants for a gardening project that allows children the joys of seeing what nature can bring. Other key projects have included establishing the Isabella Peatfield Children's Ward at Tangalle Hospital and, perhaps most importantly (according to her family), the Isabella's Playgrounds scheme. The playground has funded 16 play areas in Sri Lanka and has ensured that the little girl can stay in spirit where she was so happy.

The Peatfields have also made sure that children all over the world can enjoy the things that Bellie did. The family had been looking forward to going to see the elephants as part of their holiday adventure when the tsunami happened, so part of their fundraising effort includes t-shirts, bags and other items that help spread her love for life and the world around her to others.

The website is always updated with new projects and accepts donations that can help make other children like Isabella healthy and happy. Visit isabellapeatfield.com.

FACTS

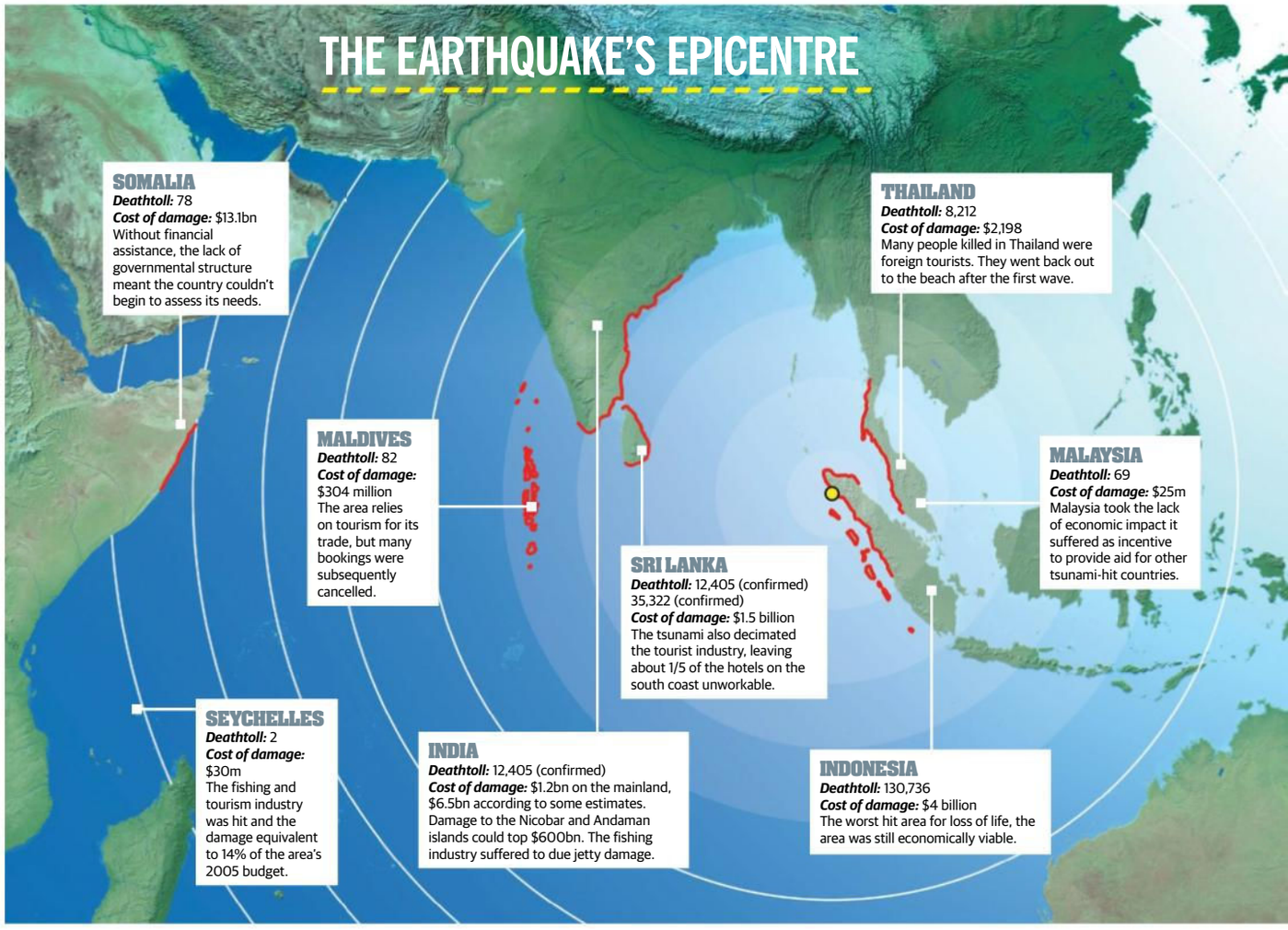
$7billion
The amount of aid money pledged to assist with rebuilding

23,000
The tsunami's power was equivalent to 23,000 Hiroshima-sized atomic bombs

800km/h
The speed the tsunami travelled in the open ocean

2000m
The distance, in meters, that the waves travelled inland

150,000
Estimated additional deaths caused by resulting infectious diseases



"In some areas, people waited in vain for help that it seemed just never came"

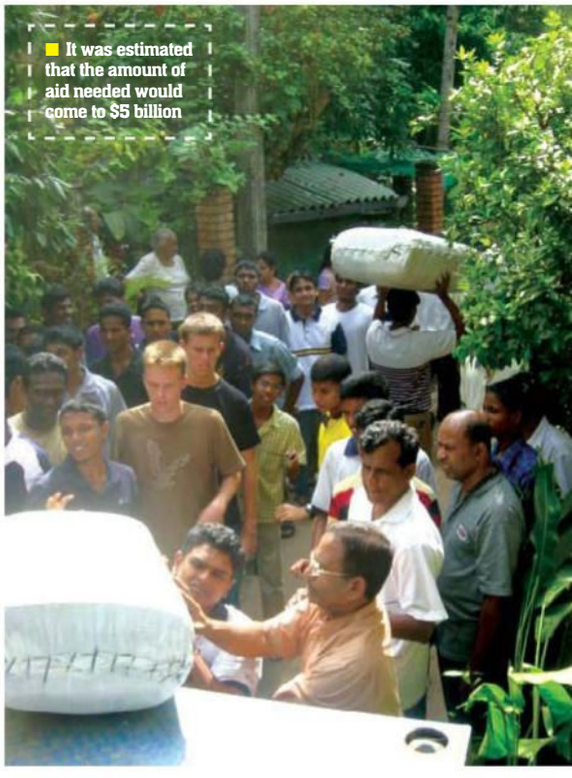
and read the regularly updated notice board to see if their family members had been saved. It fell to many of the locals to co-ordinate the initial rescue effort on the ground, later assisted by workers from the World Health Organization as well as others.

We are often taught to think of natural disasters in a religious context. In documentaries about the tsunami, survivors describe the waters as 'biblical'. If one is a believer in intelligent design - the idea that the universe is so complex that it must have been created by a God or similar being - some may think there should be an acceptance of death as the will of that creator. Others, such as tsunami survivor Amanda, weep at the idea that people who saved the lives of others could sometimes themselves be found dead. There seems so little justice in the idea that people who enjoyed the simple pleasure of the sun on a beautiful beach could essentially be punished for it.

But the wave is seen as monstrous because we personify it. We try to think of it as having the behaviours of something living to try and see ourselves as similar to it in order to try and understand and conquer it. It also reminds us of our place in the world. We try and understand it as a monster exacting revenge, like Jaws the shark, or as a sleeping beast that doesn't realise the damage it is doing but reminds us of how small and otherwise insignificant we are on the planet.

Only this is not quite the case. Thousands upon thousands of people died that Boxing Day, yet the issue can seem remote because it happened far away in a fantastical place, the set of the Leonardo DiCaprio film, *The Beach*, no less. Its gorgeous background is the magical place to which tourists run to forget the worries of the work-a-day world. Because of that, we may forget the place really exists at our peril.

Comparatively little footage of the disaster exists because people were running for their lives. They had no idea of what was about to happen. Vast swathes of the world do not have adequate


It was estimated that the amount of aid needed would come to $5 billion

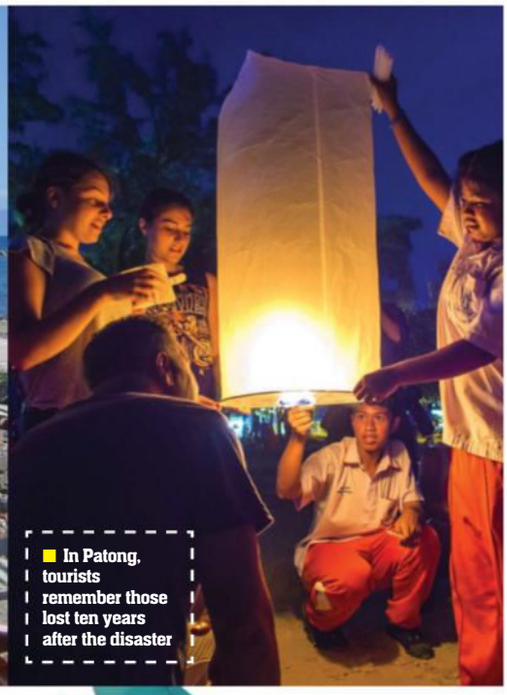
disaster prevention systems in place. The science itself is also in its infancy, so that even when the equipment to examine the physical data is available, scientists may not know how to interpret it accurately. The monitors can appear to show nothing more than incomprehensible mesh of acidic neon lines to them, just as they do to us.

Even when the scientists did finally begin to understand the potential scale of the disaster that the tsunami could cause, they were unable to warn many people because there was no single point of contact that they could call who would get the blissful sunbathers out of the storm's path with minutes to spare. The only definite way in which the storm was a judgment to remind us to care for the others who share our planet even though we are not near. We must ensure such catastrophic loss of life does not happen again.

Scientists had called for early warning systems to measure earth data in the Indian Ocean since 2003, but the plans had not been actioned. In early 2005, just following the catastrophic event, the Indian Ocean Tsunami warning system was formally put in place. Linking geographical data with diplomatic channels, it should save lives for years to come and help to prevent a repeat of the tragedy that traumatised the world and its people so many years ago.

We may always try and understand disaster with recourse to mythical beings, monsters or luck and it is beyond the power of individuals to save the world, for we are but single beings. What we can and indeed have a duty to do, however, is to remain vigilant in defence of our family across nations whether regarding storm, famine or war.

As the bravery that stood up in the wake of that terrible Boxing Day in 2004 shows, even in the face of the most savage monster that is needless destruction, humankind can still hold strong.

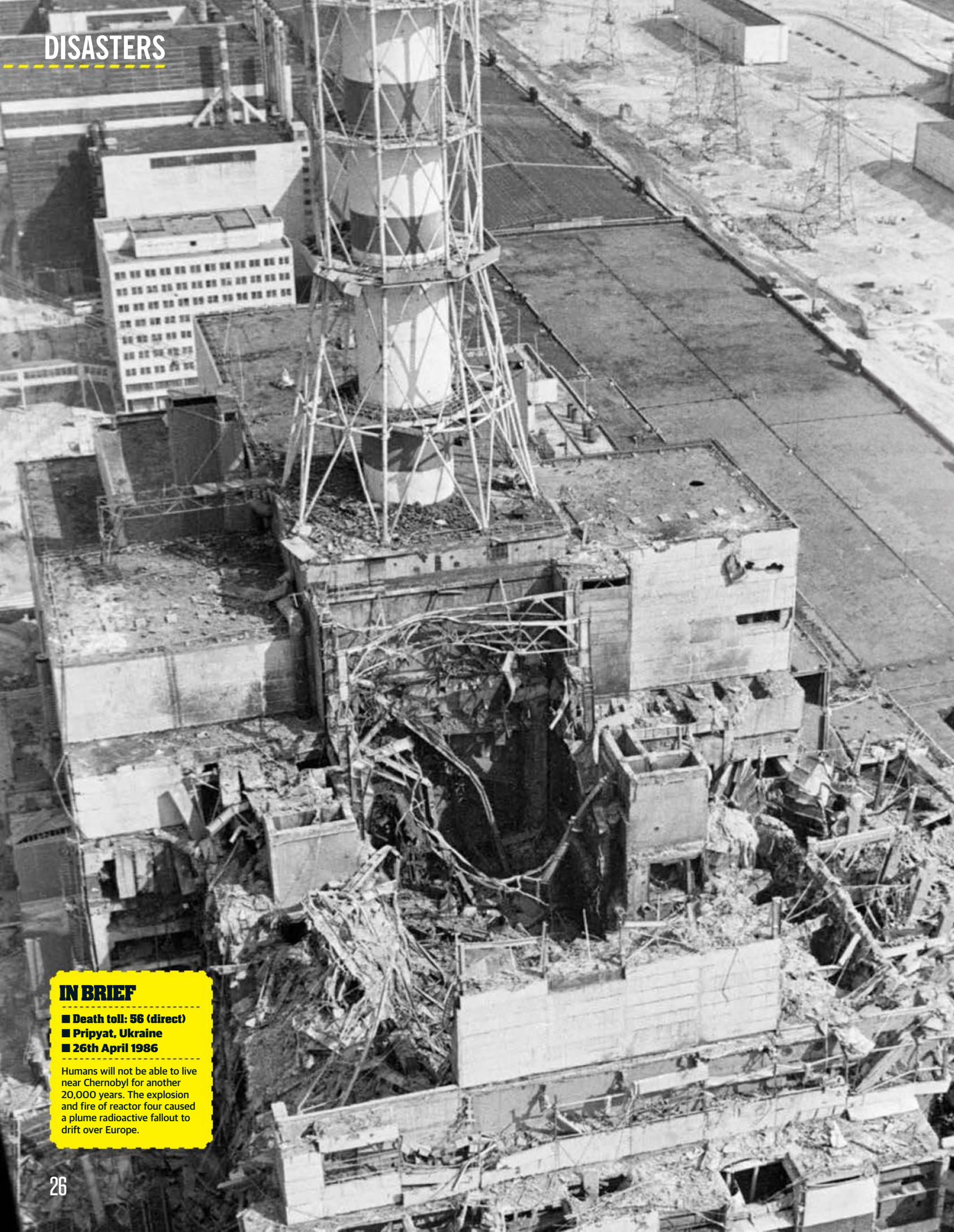


■ In Patong, tourists remember those lost ten years after the disaster

CONCORDE CRASH

2000 FRANCE

None of the 109 passengers and crew survived when Air France Flight 4590 crashed immediately after takeoff in July 2000. The scheduled flight from Paris to New York – filled with German tourists – plunged to the ground after a mechanical failure caused debris to litter the runway. A tyre blew, a fuel tank was punctured and a fire caused the engine to fail. The Concorde fleet was grounded pending investigation, and in 2003 they were retired altogether.



IN BRIEF

- **Death toll: 56 (direct)**
- **Pripyat, Ukraine**
- **26th April 1986**

Humans will not be able to live near Chernobyl for another 20,000 years. The explosion and fire of reactor four caused a plume radioactive fallout to drift over Europe.

THE CHERNOBYL MELTDOWN

A seemingly routine safety check led to the worst nuclear accident of the 20th century and helped bring about the end of the Soviet Union

Thirty years ago, the world came to understand all the horrifying implications of a nuclear disaster. To many, this gargantuan industrial monster known as the Chernobyl nuclear power plant, constantly spewing out smoke and power, was a sign of the Soviet Union's towering ambitions. Situated in Ukraine, approximately 16 kilometres northwest of the city of Chernobyl, work began on the plant in the Seventies. By 1984 four reactors were active. Each reactor was capable of producing one gigawatt of electricity and the plant itself provided approximately 10 per cent of Ukraine's electricity. But the Soviets weren't stopping there. By 1986 two more reactors were being constructed, with ambitions to make Chernobyl one of the world's largest nuclear power stations.

The plant also provided a living for the local inhabitants and numerous people had moved into the region because of their work with the nuclear power station. In fact, the town of Pripyat had been built in 1970 to house almost 50,000 plant workers and their families, less than two miles from the sprawling power station. It may have looked industrial and ugly, but it was good for the region's economy and served as a symbol that the Soviets were as technologically advanced as any of the decadent countries in the west.

One of the men who earned their living from the plant was Aleksandr Akimov, a night shift supervisor. On 26th April 1986, he was in charge of a routine safety test on reactor four. In less than two weeks time he would be dead from severe radiation poisoning from the worst nuclear accident of the 20th century.

The plant may have been highly effective at generating power, but safety concerns had been raised. The four reactors were of the Soviet RBMK design, which produced both plutonium and electric power. This meant that they were different from standard commercial designs, as they employed a

This hotel in Pripyat has not seen guests since the accident in 1986

unique combination of a graphite moderator and water coolant. Adding to these safety concerns, the reactors were unstable at low power, primarily owing to control-rod design.

In 1986 the Soviet Union was an 'interesting' place. In five years' time its communist structures would come unceremoniously crashing down and the Soviet Union would be dissolved, leading to the biggest change in the country for a generation. However, at the time of the Chernobyl disaster, the old mechanics of government were still clinging on and the old adage, 'knowledge is power', was at the heart of the government's policies. There were those who were concerned – although given how seriously the Soviet administration took secrecy the numbers in the know were limited – that the Chernobyl plant did not have the massive containment structure common to most nuclear power plants elsewhere in the world. This meant that if an accident occurred, radioactive material would not be contained, but seep into the environment and cause untold damage to people and natural surroundings.

This secrecy ran not just to the knowledge held by other countries, but also to their own people. Aleksandr Akimov's superior was Anatoly Dyatlov, deputy chief engineer. When the Soviet Union's authorities later tried Dyatlov, desperately looking for scapegoats, he stated that he did not know of the previous accidents that had occurred at reactors of the same type, even though several had. It may seem strange that the authorities wouldn't want those in positions of authority to possess all of the pertinent facts about the equipment they were working with, but such was the culture.

There are conflicting reports about the circumstances of the disaster, with some claiming that Akimov and other engineers were reluctant to carry out the test but were pressured into doing so by Dyatlov. Dyatlov later countered this and said the atmosphere in the plant was normal and no one was anxious about the test proceeding. The test was to examine whether the reactor could operate under electricity generated by its own turbines and produce a backup source of electricity to keep the reactor going in the event of a general power failure. Several safety features that could have interfered with the test were deliberately turned off.

The test began and it became apparent that something was wrong. The emergency shutdown button was pressed. Nothing happened.

In an interview later Dyatlov said of the incident: "I thought my eyes were coming out of my sockets. There was no way to explain it. It was clear this was not a normal accident, but something much more terrible. It was a catastrophe."

After only a minute reactor four's roof was suddenly blown off into the air, and radiation began seeping out of it. The dozen people in the control room – including Akimov and Dyatlov – were exposed to shocking levels of radiation and

GHOST TOWN

The town of Pripyat is located a mere 1.8 miles (three km) away from the nuclear power plant and had a population just under 50,000 at the time of the Chernobyl disaster. It was a growing town with 15 primary schools, five secondary schools, a hospital and sports and recreational facilities, including an Olympic-sized swimming pool. After the accident, residents were evacuated but told they could return in three days time, meaning that many possessions are still in the city to this day. Some residents have returned to the area, but none have been allowed back into the town, as it is still quarantined due to high levels of radiation.

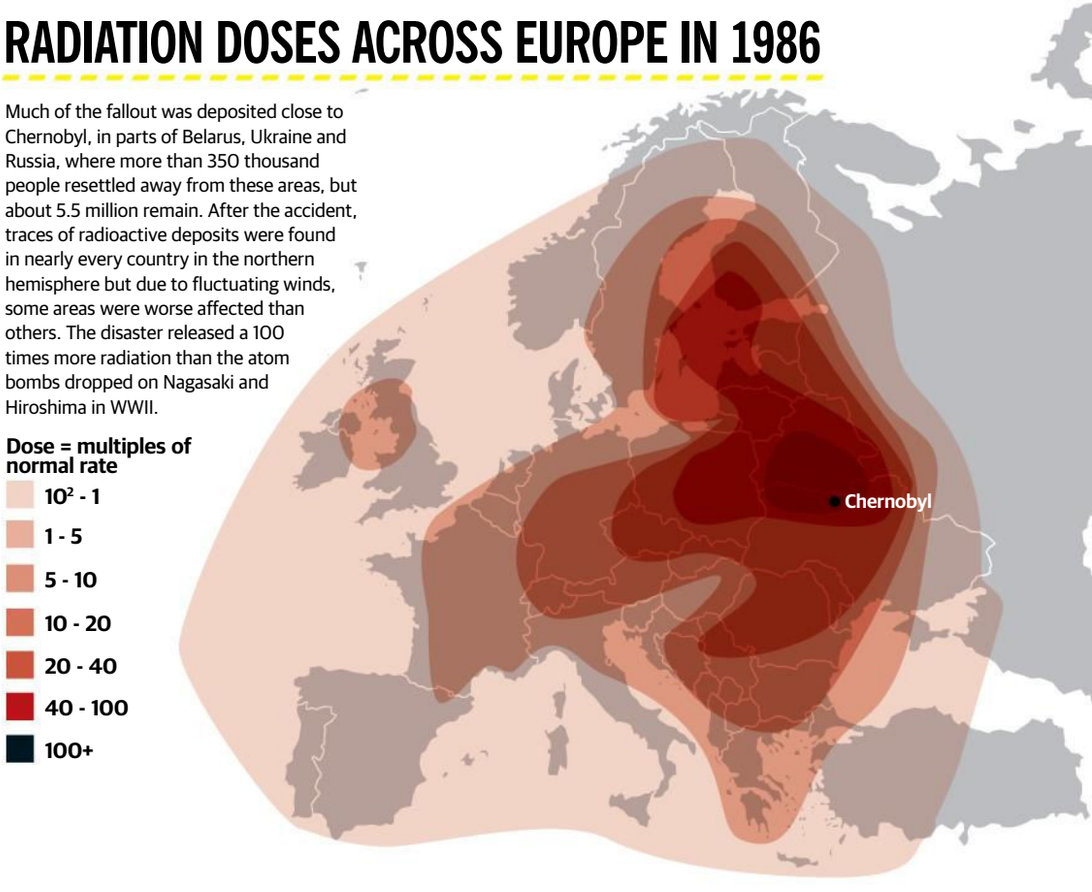
The city is a historical monument to life in the Soviet Union in the Eighties: the walls still display propaganda slogans and the houses and factories speak of a different era. In some parts nature is reclaiming areas, and in 2002 the city opened as a slightly macabre tourist destination for those willing to sign a waiver in case they suffer or die from radiation poisoning.

five of them died soon afterwards from radiation burns. The radiation levels in the worst-hit areas of the reactor building have been estimated to be 5.6 roentgens per second (R/s). A lethal dose is around 500 roentgens over five hours, meaning that some workers received fatal doses in less than a minute. Unfortunately for those working in the contaminated area, a dosimeter (which measures an individual or object's exposure to radiated energy) capable of measuring up to 1,000 R/s was buried in the rubble of a collapsed part of the building, and another one failed when turned on. All remaining dosimeters had limits of 0.001 R/s and simply read 'off scale'. Therefore, the reactor crew could only ascertain that the radiation levels were somewhere above 0.001 R/s and did not have confirmation of the truth: that the radiation was life-threatening.

Due to these inaccurate low readings, Akimov assumed the reactor was intact – although to come to this conclusion he ignored the assorted pieces of graphite and reactor fuel lying around the building and the high readings of another dosimeter brought in that was dismissed as 'defective'. Whether Akimov really thought the reactor was intact or he knew the importance of averting further disaster is mere conjecture. What is fact is that he stayed with his crew in the reactor building until morning, sending his crew to try to pump water into the reactor, none of them wearing protective gear.

RADIATION DOSES ACROSS EUROPE IN 1986

Much of the fallout was deposited close to Chernobyl, in parts of Belarus, Ukraine and Russia, where more than 350 thousand people resettled away from these areas, but about 5.5 million remain. After the accident, traces of radioactive deposits were found in nearly every country in the northern hemisphere but due to fluctuating winds, some areas were worse affected than others. The disaster released a 100 times more radiation than the atom bombs dropped on Nagasaki and Hiroshima in WWII.



Health physicists in special suits controlling radiation in the fields of the Chernobyl disaster area

"Radiation was now leaking out of the plant on an unprecedented scale, and the Soviet's reluctance to share information would lead to further loss of life"

FACTS

50,000
People working as 'bio-robots' engaged in the clean up

15
The amount of days the fire in reactor four continued to burn

30 YEARS
Since the accident occurred in Pripyat

350,400
People evacuated from the most contaminated areas

60%
How much of the deadly nuclear fallout landed in Belarus

The radiation leak wasn't the only danger. In flagrant disregard of safety regulations, a combustible material, bitumen, had been used in the construction of the reactor building and turbine hall's roof. Parts of the exploded roof from reactor four landed onto the roof of the still-operating reactor three and several fires sprung up, dancing on its roof. A Chernobyl Power Station firefighter brigade was first on the scene to try and extinguish the flames; with the main objective to douse the fires around reactors three and four, and ensure that reactor three's cooling system was kept intact.

One of the firefighters was Lt Col Leonid Telyatnikov. In an interview with *People magazine* years later he recalled: "It was a clear night with lots of stars. I had no idea what had happened, but as I approached the plant I could see debris on fire all around, like sparklers. Then I noticed a bluish glow above the wreckage of reactor four and pockets of fire on surrounding buildings. It was absolutely silent and eerie." The firefighters managed to control the blast, but with none of them wearing any radiation protection it was inevitable there would be casualties, especially for those combating the flames on the roof. Six of the firefighters died following their exposure and many others suffered long-lasting damage. It's hard to overstate the importance of their actions; an explosion in reactor three could have led to the destruction of all four reactors and the world would have faced a far greater disaster.

Further catastrophe may have been averted due to the bravery of the plant engineers and firefighters, but radiation was now leaking out of the plant on an unprecedented scale in modern history, and the Soviets' reluctance to share information – even when their citizens were at risk – would lead to further loss of life. The nearby city of Pripyat was not immediately evacuated after the incident and with the townspeople oblivious to events just down the road many of them fell ill and complained of a metallic taste in their mouth before suffering uncontrollable fits of coughing and vomiting. Soviet authorities started evacuating people from the area around Chernobyl within 36 hours of the accident and told the people who were forced to leave their homes that it was only a temporary measure and that they were safe in leaving behind personal possessions. A month later all those living within an 30 kilometre (18 mile) radius of the nuclear power plant – over 100,000 people – had been relocated.

The actions of the local Soviet authorities in evacuating the surrounding area were slow, but they were positively proactive compared to the national response. The general population weren't actually informed of the incident until several days later, and even then it was a cursory 20-second announcement on a TV news program stating: "An accident occurred at the Chernobyl Atomic Power Plant and one of the reactors was damaged. Measures have been undertaken to eliminate the consequences of the accident." The only reason this statement was made was because of events occurring in Sweden.

On Monday 28th April, 55 hours after the explosion at reactor four, an alarm sounded at the Forsmark Nuclear Power Station in Sweden; high

Construction of the confinement arch for Chernobyl's reactor four won't be finished until at least 2016

A DISASTER STILL WAITING TO HAPPEN?

The effects of the Chernobyl disaster are still widely felt, with different agencies varying in their estimates of the amount of deaths it caused. The World Health Organisation put the figure at 4,000 whereas Greenpeace believe it is at least 10,000 and perhaps considerably higher. The economic costs have also been high, with Mikhail Gorbachev claiming the Soviet Union spent 18 billion rubles on containment and decontamination, virtually bankrupting itself, and costs are still ongoing. There are fears that because of these economic costs the world could be sleepwalking into another disaster.

The long-term plan for the containment of reactor four is the New Safe Confinement (NSC), a 20,000-ton steel arch intended to prevent any radiation leakage into the environment for the next 100 years. The structure will be 190 metres (623 feet) wide and more than 100 metres (328 feet) high. Initial plans were for the NSC to be in place by 2005 but recent reports suggest this will not happen until 2016 at the earliest. A hastily-built sarcophagus has sheltered the reactor since 1986 but there are genuine and serious concerns over its long-term effectiveness.

Despite different governments pledging to help pay for the work to be completed, with the NSC currently eight years behind schedule there are those who fear that the work will never be finished and that the current sarcophagus will begin leaking dangerously high levels of radiation. Then Chernobyl will be the scene of its second nuclear disaster.

amounts of radioactivity were being detected and workers were evacuated. As the alarm sounded other nuclear power stations across Scandinavia also detected high radiation levels coming from an incoming nuclear cloud that had originated in the Soviet Union. When asked for an explanation, the Soviets Union's response was predictable; they denied anything had happened. It was only after the Scandinavian countries had announced the source of immense radiation that Moscow issued the statement above.

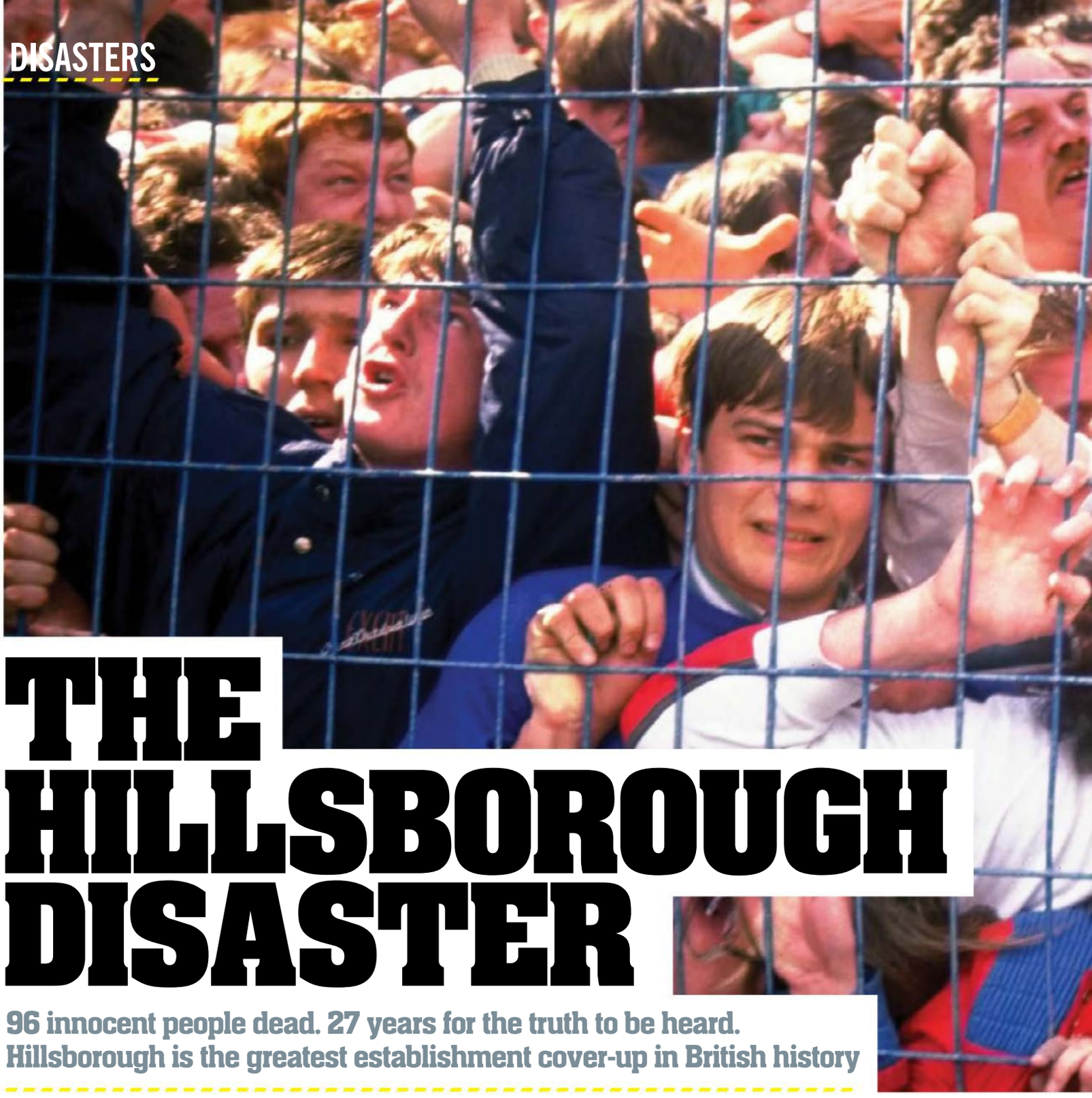
The day after the incident, a government commission was set up and reactors one and two were shut down. A Soviet officer, General Pikalov, set out in a truck fitted with radiation apparatus and rammed through the closed gates to measure the radiation. He established that the graphite in the reactor was burning and that it was giving off an enormous amount of radiation and heat. Shortly afterwards, the town of Pripyat evacuated but further mistakes were then made.

First, extinguishing water is added but the high temperature separates the water into hydrogen and oxygen and the resultant explosion releases heat. Thus, the fire is not extinguished but fanned. After three fruitless attempts, the authorities throw sand, lead and boron carbide onto the reactor from helicopters. This causes the temperature to drop but all those in the helicopters died soon after – of unrelated causes, according to Moscow. Ten days passed until the reactor core was fully extinguished.

With the fire out, those in power began looking for people to blame. To point the finger at substandard equipment would have been tantamount to admitting that the mighty Soviet Union lagged behind its world competitors in matters of technology or safety. It was far better to put the blame on human error. Over 25 members of the Communist Party were expelled for their 'role' in the disaster and six Chernobyl workers were accused of violating safety rules during experiments on reactor four. Dyatlov was accused of sending four subordinates to inspect the burning reactor without telling them of the radiation hazard. All of them were found guilty.

The government finally had their scapegoats but, just like the radiation leaking out of reactor four, the political consequences of the accident could not be contained and one of the consequences of the Chernobyl disaster was the eventual demise of the Soviet Union.

The disaster at Chernobyl caused great suffering but was also a turning point in the Soviet Union's history and ultimate dissolution. It proved that, towards the end of the 20th century, a Western government that seemingly cared so little for the safety of its citizens was no longer sustainable. As the last Soviet president, Mikhail Gorbachevh, himself later wrote: 'The Chernobyl disaster, more than anything else, opened the possibility of much greater freedom of expression, to the point that the system as we knew it could no longer continue.'



THE HILLSBOROUGH DISASTER

96 innocent people dead. 27 years for the truth to be heard. Hillsborough is the greatest establishment cover-up in British history

The roar of the crowd on match day can send shivers down the spine. Tens of thousands of men, women and children cheering on their beloved team with a cacophony of chants, songs and yells. Nothing can equal it; nothing comes close.

Football is often described as the 'Beautiful Game', and it is. The joys and sorrows of your team are shared by supporters at home and abroad in the days, weeks and months of a footballing season. Then it all starts again after the summer break. Every goal. Every chance missed. Every perfect pass. Every terrible pass. Reactions to these events are in sync. Other sports share a sense of togetherness, but not like football. There is a profoundness to the unity among football fans – often people from all walks of life united behind one passion and obsession: to see your heroes do well week in, week out.

There are times when football feels like the be-all and end-all. As manager Carlo Ancelotti put it: "Football is the most important of the least important things in life." Liverpool fans would delight in Bill Shankly's famous quote: "Some people believe football is a matter of life and death, I am very disappointed in that attitude. I can assure you, it is much, much more important than that." But not anymore.

15th April 1989 is a date etched in history as a terrible day. What should have been just another match became a national trauma. Not only is Hillsborough a monumental tragedy; it's the story of how the establishment manipulated their power base to advance their own narrative, protect themselves from prosecution and smear innocent people.

In the Eighties, Liverpool FC was unstoppable, and Anfield a fortress. The Reds swept up cups and league titles in a way that only Manchester United's

IN BRIEF

- **Death toll: 96**
- **Sheffield, UK**
- **15th April 1989**

Due to police incompetence and a serious lack of crowd control, when a set of gates were ordered open to alleviate a crush developing outside the turnstiles, tragedy followed.

ascendency under Alex Ferguson would replicate during the nascent Premier League era. As in 1988, Kenny Dalglish's team were to face Nottingham Forest in the FA Cup semi-final. But as anticipation and excitement whirled through the stands, a crush was developing outside the turnstiles at the West Terrace entrance, known colloquially as the 'Leppings Lane end'.

As the game edged closer to kick-off, people held up in traffic and who had arrived by train, then ferried to the ground by coach, were making their way to the stadium. There was little police presence at the turnstiles – nowhere near the numbers expected – and those who were there would rapidly lose control of the situation. There was no organisation, no methods to corral people, or any implementation of a plan to break up the flow. Instead, it was allowed to turn into bedlam. Radioing to their commanding officers in the control tower overlooking the West Terrace, constables were met with indecision and silence. A plea was made to alleviate the pressure on the turnstiles by opening Gate C. More indecision followed. More crowding. More crushing. One officer lost his rag and did something a bobby is never supposed to do – he swore down the radio for all to hear: "Open the fucking gate or somebody will be killed."

How an inexperienced, wholly out of-his-depth Chief Superintendent ended up as match commander during the biggest event in South Yorkshire Police's calendar, with a third of the force assigned to cover it, began with a hazing prank. In late October 1988, a probationary constable was called out to a property in Ranmoor, Sheffield. He'd gone there after dark upon receiving information about a possible burglary. There, he was confronted by two masked men armed with weapons. The young copper was handcuffed,

verbally abused and his photo taken as he cowered on the ground, fearing for his life. When the assailants removed their masks and began laughing hysterically, he realised that he had been on the receiving end of a cruel joke; a sort of initiation test. He was 'one of them', now. Not seeing the funny side at all, he went home traumatised, told his wife and made an official complaint. Heads rolled, unlike in the aftermath of Hillsborough. Four constables were sacked, and the head of F Division, located at Hammerton Road and in charge of match days at Sheffield Wednesday's ground, Chief Superintendent Brian Mole, a man with strong experience of policing games, was sent off to Barnsley for 'career development' on 27th March.

Sheffield news reporters attended a pre-match press conference held by Duckenfield, and felt he wasn't up to snuff when he couldn't even get the names of the teams right (he referred to Nottingham Forest as "Nottinghamshire"). Constable Martin McLoughlin, attending a briefing on the morning of the game, commented in 2015 television documentary *Hillsborough* that Duckenfield was the type who "liked the sound of his own voice." How ironic, then, that he froze at the moment he should have been giving orders and commencing the emergency disaster plan.

The crush outside the Leppings Lane turnstiles was getting worse. Duckenfield – finally – ordered Gate C open to take the pressure off the situation. This was at 2:52pm. Far from making things better, it caused the biggest peace-time disaster in Britain.

In previous years, the central tunnel was blocked off or closed, preventing fans from using it when full. Not this time. Due to poor signing and the confusing layout of the ground, fans poured in and headed straight down the tunnel. Nobody was there to stop them, or to tell them that the pens were full, which could have been relayed to constables in the concourse behind the stand. Duckenfield said he could not see the Leppings Lane concourse or turnstiles from his position in the tower. But he could see almost directly into pens 3 and 4, and the crush that was developing right in front of his eyes. It should have been obvious, but it wasn't to Duckenfield, because he assumed that's what happens at a football match: people are packed in like sardines and "find their own level", as he described it. Due to the lateral fencing between the terraces, fans could not move sideways. A deadly crushed developed.

The noise of the crowd was punctuated by sounds that do not belong at a sporting event. They were more suitable to a battlefield: crying, groans, screaming, death sighs, then silence. Nobody is quiet at a football game. Everybody flaps their gums, offering a running commentary with every kick of the ball, or they're busy singing, in an effort to will their team on. If it wasn't immediately clear to all Liverpool and Nottingham Forest fans in the North, South and Spion Kop stands that something wasn't right in the lead up to the 3pm kick-off, then the sight of people clambering desperately over the metal fences at the West Terrace made this clear soon enough.

"You saw faces pressed against the fence and people saying, 'Bruce, can you help us?'"

An ambulance finally makes its way through the crowds and onto the pitch

Liverpool players were initially dismayed to see fans running onto the pitch. Goalkeeper Bruce Grobbelaar went to fetch a ball and saw for himself what was happening. "You saw faces pressed against the fence and people saying, 'Bruce, can you help us?'" When two blokes approached Liverpool's captain, Alan Hansen, he started to castigate the distraught figures for invading the field of play. "Al, there are people dying in there," they told him. He couldn't believe what he was hearing. The game was stopped at 3:06 pm.

Hillsborough claimed 96 lives in total, with hundreds more injured. For survivors, physical ailments faded to be replaced by psychological ones. Feelings of guilt and terror took root. Night-times were the worst: the dreams, the cruel replays of panic and fear. Yet neither was there time to mourn or make sense of what had gone on, for survivors were recast in new life-long roles as victims of a disaster, but also told they were responsible. In reality, it was caused by South Yorkshire Police's incompetence, mismanagement and negligence.

Hillsborough would provide a catalogue of excessive and often needless post-event horrors. Families and survivors wanted answers, but were denied. Instead, an alternative but powerfully convincing lie was invented by South Yorkshire Police, aided and abetted by the press. Compassion was limited. Lies were treated as indisputable facts: Liverpool fans were to blame, and must accept their part and stop going on about it all the time. "Liverpool people killed Liverpool people," as Nottingham Forest manager Brian Clough put it.

The smears and cover-up began right away, thanks to Chief Superintendent Duckenfield. In years to come, the country and world would learn how evidence would be concealed, constables' statements were vetted and rewritten to remove all criticism of South Yorkshire Police's senior officials, witness statements would be signed by officers or investigating teams without actually having been present at the interview, a video camera looking straight into the pens - with a powerful zoom lens - was said not to be working (it was) and tapes went missing. This was a cover-up by corrupt officers whose arrogance and behaviour in the face of catastrophic failings was to deny it wholesale. No ifs, buts or maybes. South Yorkshire Police, our public servants, deemed themselves our masters. "What we say goes" was their attitude.

FA executive Graham Kelly made his way into the control tower after seeing the game brought to a halt. He asked what was going on, and Duckenfield informed him that Liverpool fans had forced open Gate C, causing the subsequent mayhem in pens 3 and 4. In a few brief words he crafted a devastating myth, one that held steadfast

WARNING SIGNS AT HILLSBOROUGH STADIUM

Football grounds represent not only a community, but an identity. The location of a stadium is hugely important in cementing the identity of a team and its supporters. Hooliganism is a nightmare product of fandom, and it's why it led to the obsession with 'containment' instead of safety.

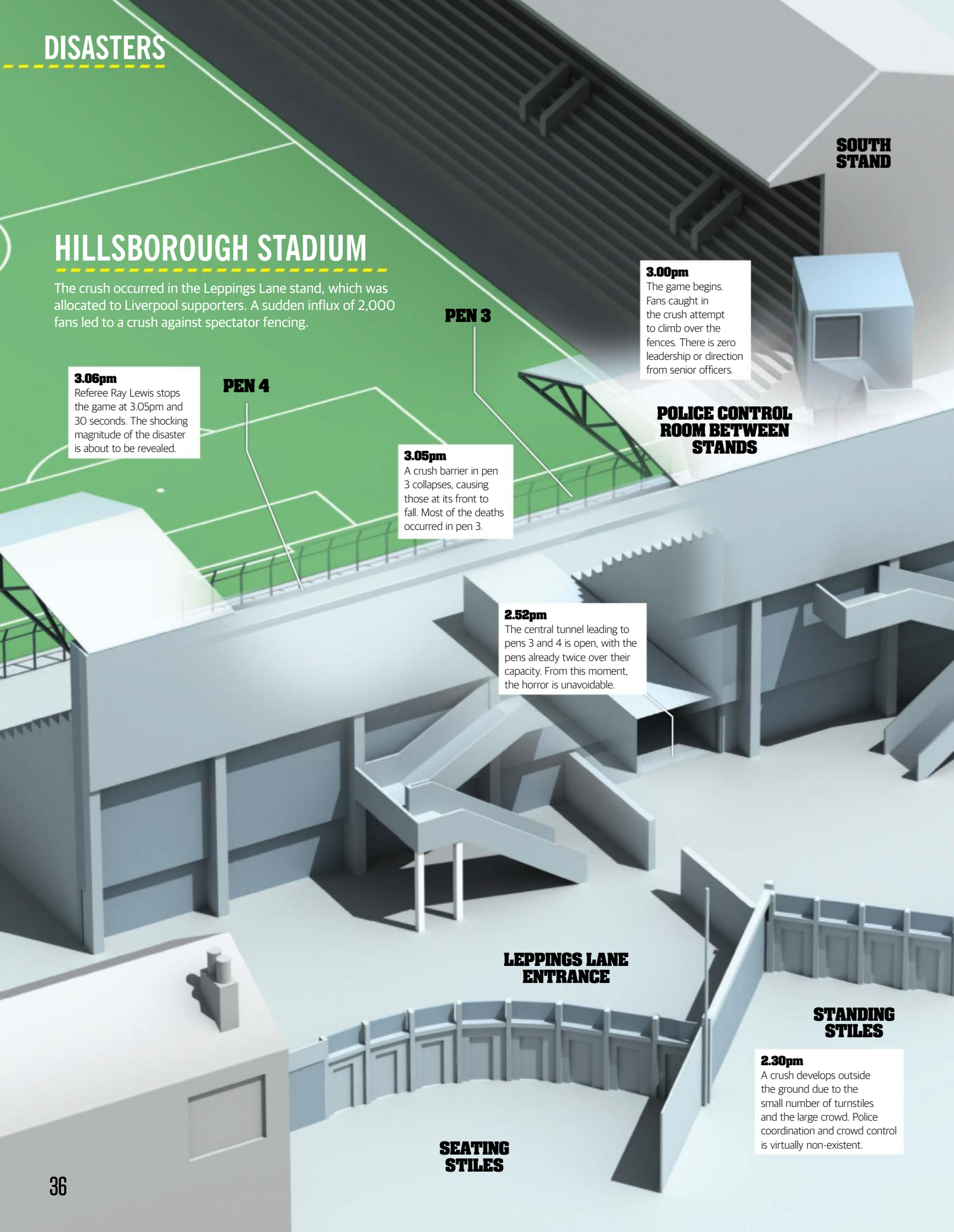
As years pass, a stadium can be rendered obsolete because of increased demands on infrastructure. Some are deemed unfit for purpose. Hillsborough in 1989 was one such example. Here and there, features had been 'upgraded' over the years – crash barriers, radial fencing, seats, pens and gates – due to recommendations from several governmental reports, but what these places need most of all is a police force operating at their very best, and stewards visibly deployed at all exits and entrances. Hindsight can be cruel, as if Hillsborough was a ground primed for incident due to neglect (its safety certificate had not been updated since 1979).

One of the stupidest things a person can ever exclaim in response to Hillsborough, no matter how much in good faith, is that it brought in the era of all-seater stadia, and that was something good and positive derived from such a momentous calamity. Such a remark or philosophy does little to honour the dead.

During the 1981 FA Cup tie between Tottenham Hotspur and Wolverhampton Wanderers, held at Hillsborough, there was a crush in the Leppings Lane central pens. On this occasion there were no deaths, and police let fans who had climbed over the high steel fencing watch the game from the side of the pitch and behind the goalmouth. Overcrowding was reported not only at the 1988 Liverpool v Nottingham Forest FA Cup semi-final tie at Hillsborough, but during the 1987 match, when Sheffield Wednesday played Coventry City. Still, nothing was done, and no warning signs heeded.

HILLSBOROUGH STADIUM

The crush occurred in the Leppings Lane stand, which was allocated to Liverpool supporters. A sudden influx of 2,000 fans led to a crush against spectator fencing.



3.00pm
The game begins. Fans caught in the crush attempt to climb over the fences. There is zero leadership or direction from senior officers.

3.06pm
Referee Ray Lewis stops the game at 3.05pm and 30 seconds. The shocking magnitude of the disaster is about to be revealed.

3.05pm
A crush barrier in pen 3 collapses, causing those at its front to fall. Most of the deaths occurred in pen 3.

2.52pm
The central tunnel leading to pens 3 and 4 is open, with the pens already twice over their capacity. From this moment, the horror is unavoidable.

2.30pm
A crush develops outside the ground due to the small number of turnstiles and the large crowd. Police coordination and crowd control is virtually non-existent.

2.47pm
A request comes in at 2.47pm to open Gate C in order to relieve the crush. Chief Superintendent David Duckenfield gives the command at 2.52pm.

GATE C

Supporters attempt to lift out friends and strangers from the crowd.

"Hillsborough would provide a catalogue of post-event horrors"

for years, and spearheaded and shaped South Yorkshire Police's response to the disaster.

The shadow of the Heysel disaster provided the perfect cover and excuse for the South Yorkshire police to behave the way they did against Liverpool fans. The 1985 European Cup tragedy saw 38 Juventus supporters killed by a collapsing wall, when some Liverpool supporters rushed at opposition fans in a section supposedly reserved for neutrals. Several bitter skirmishes over the course of an ill-tempered day led to a deadly end result (in another football stadium not fit for purpose).

The political establishment and media were fixated on football hooliganism during the Seventies and Eighties, and believed it to be endemic. At a time when it was still seen predominantly as a working man's game, supporters were often tarred with the same hooligan brush. The reality was much different, and neither was Liverpool's home or travelling support known for football violence, despite what Heysel looked like. 'Drunk, ticketless fans caused Hillsborough' was repeated chapter and verse by the establishment, and wormed its way into popular opinion. There is evidence that some fans knew what was coming. A BBC camera captured a group of men waving their tickets to the camera. Their protest was in vain. Duckenfield's lie rapidly spread to the media, and the BBC's coverage repeated the claim that "a gate had been broken open at the Leppings Lane end of the ground, enabling non-ticket holders to flood in." Yet Duckenfield's lie was known from the start; it just wasn't treated as one. In a television interview, given to the press by Kelly, he explained that he'd heard "two versions". One is the forced gate scenario (Duckenfield's lie), and the other that somebody in a position of authority had ordered the gate open (the truth).

South Yorkshire Police moved like lightning to get their version of events onto the airwaves, into the homes of the nation and in the newspapers. Sheffield's White's News Agency originated false reports about drunk, ticketless fans and individuals picking the pockets of the dead and urinating on coppers trying to rescue those in need. One 'credible' source was Irvine Patnick, MP for Sheffield Hallam, who told officers in the makeshift mortuary located in Hillsborough's gymnasium, "I spoke to many policemen." He continued, "They told me they were hampered, harassed, punched, kicked and urinated on by Liverpool fans." The MP also stated, "They had no reason to lie", and "There is no doubt in my mind it is true." White's News agency's make-believe fantasies were the source of *The Sun*'s front-page headline, arguably the most controversial in British press history. Emboldened by what he had been told, editor Kelvin Mackenzie sat in his office and dreamed up: 'The Truth'. Staff were uneasy and others plain disgusted. But their boss was adamant that they were running with it in the morning's

FACTS

54,000
fans attending the match

Number of police on duty:
1,122

10 The age of the youngest victim, Jon-Paul Gilhooley

38 Number of victims aged 19 and under killed

Total number of non-fatal injuries **766**

89 male victims, **7** female

Leppings Lane terrace capacity
10,100

paper. *The Sun*, however unwittingly, was playing the role of South Yorkshire Police's PR firm.

The Star, a Sheffield newspaper, offered perhaps the only accurate report from the ground that afternoon and long hours that followed. In its special Sunday edition covering the tragedy, it highlighted Duckenfield's decision to open Gate C, calling it "a moment of madness." Lord Justice Taylor, in charge of the first inquiry, offered a damning verdict of South Yorkshire Police while managing to reach all the wrong conclusions. Duckenfield's blatant fabrication was obscured by a smear campaign that allowed prejudice and opinion to ride roughshod of the facts.

Survivors were treated like suspects in a crime. In a vile abuse of power, South Yorkshire Police used computer records to check the backgrounds of the victims. Was there anything they could use to impugn the dead or help the cause in protecting the force against possible recriminations? Alcohol played no part in Hillsborough, but coroner Dr Karl Popper's decision to take the blood sugar levels of all victims - including children - further provided ammunition for the smears. The 2012 inquiry later found that there was no rationale or precedent for Popper's action. What emerged was a clear bias, a type of class warfare aimed at the city of Liverpool - even though Hillsborough was a nationwide tragedy affecting both middle and working class people - and a police force unwilling to accept that they caused the disaster when they knew they were at fault.

Of course fans had been drinking. Football is a social event. Only in the fevered world of Eighties hooliganism would drinking beer before a match be seen as problematic. It demonstrated a lack of establishment understanding of a country's pastime and culture. "How much did you have to drink?" became a line of questioning by officers

Prime Minister Margaret Thatcher with aides and South Yorkshire Police seniors at Hillsborough

CREATING THE SELF-PITY CITY

What made the smear campaigns and police corruption so successful for so long was the self-pitying victim status bestowed upon Liverpool. A once thriving world port in decline for decades, a common view was that people in the city were somehow their own worst enemy. Militantly left-wing in a time of Thatcherism, with unemployment figures through the roof, a sort of collective antagonism and snobbery was aimed at the city. "Scousers would blame anybody but themselves" was *di rigueur* rhetoric.

The media took a major role in shaping this viewpoint via columns and 'thinkpieces' – not just in right-wing newspapers, but also in more traditionally left-leaning broadsheets like the *Guardian* and *Observer*. Sympathy and understanding was in short supply. It was as if the rest of the country turned their shoulder against Liverpool, paternalistically telling them to buck up and stop whining about their lot.

Not only had Hillsborough been lumped with the Heysel tragedy as examples of a city unable to accept blame; when James Bulger went missing in 1993, the city was in the headlines again. Here was another opportunity to stick the knife in further, to repeat the charges and condemn what they saw as a maudlin outpouring – not a strong community that lived together and suffered together in times of economic strife and misery. In 1993, a *Sunday Times* article written by Jonathan Margolis, headlined 'Self-Pity City', went to town: "Liverpool culture seems nevertheless to thrive on defeatism and hollow-cheeked depression with a cloying mawkishness."

There are plenty of examples like that: all willing to put the boot in. All taking an unsuspecting part in an establishment cover-up because they refused to believe what Liverpool was telling them: Hillsborough was a disaster caused by those with a duty of care.

taking statements. "How much did *they* have to drink?" if the person being interviewed was a relative of the dead.

A few people might well have been drunk, but nobody – fans or constables – witnessed anything out of the ordinary, or the latter thought it worth pulling anybody for. Being drunk does not make you a criminal unless you act criminally. Nobody acted like a criminal that day. But the idea was set regardless of fact: a booze-fuelled mob without tickets violently pushed their way into the grounds. Photographs taken on the day do reveal confiscated drinks in bins dotted by turnstiles. They are predominantly soft drinks; cans of Coke and other sugary beverages, the odd can of lager among them.

Hillsborough was an FA Cup semi-final turned tragedy turned establishment cover-up turned national disgrace. It threw into question everything we are led to believe about those with a duty of care towards our well-being. But also, justice being a malleable concept when those with power are criticised or in the wrong; the absence of common decency and empathy from those with power; and the reasonable assumption those in the wrong are punished.

What typically happens when those with power over our lives get it wrong is that justice is evaded for as long as possible. This is where establishment arrogance and backside-covering, for want of a better phrase, comes into play. Suddenly, the goal posts shift and everything we hold dear about the rule of law and punishment become amorphous and re-moulded to fit a new story or perception. Blanket denials become cast-iron, irrefutable facts. Hillsborough's story is an example of what happens when those in charge screw up spectacularly and then refuse to carry the can until they are exposed after decades of perseverance for their crimes. 'You'll Never Walk Alone' isn't just a pre-match Anfield tradition; its lyrics post-Hillsborough attained an immense symbolic power. "When you walk through a storm, hold your head up high, and don't be afraid of the dark." To put it bluntly, the political establishment and media picked on the wrong city.

The legal maxim – *Fiat justitia ruat caelum* (Let justice be done though the heavens fall) – was made a mockery of by South Yorkshire Police, the West Midlands Police investigative team and the Home Office. South Yorkshire Police did their very best to evade acceptance, and stuck to their story about 'tanked up' fans and hooliganism, besmirching the dead all over again. This behaviour, accepting failings one minute and then repeating old lies the next, is astonishing today.

"South Yorkshire Police used computer records to check the backgrounds of the victims"

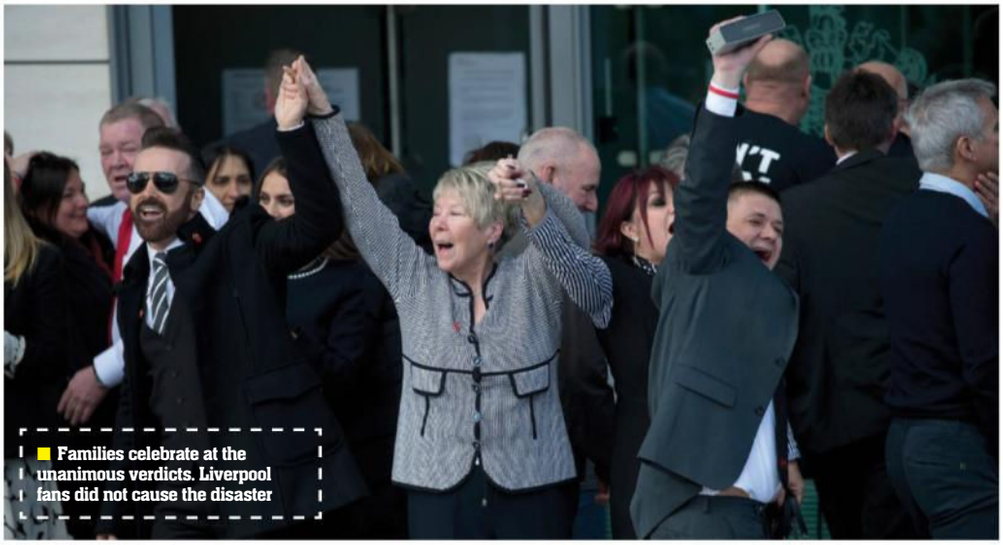
The proposal that those with a duty of care towards us would seek to manipulate and cover up their mistakes is difficult for the British public to accept. We are a nation with an at times egregious respect for the establishment. This works entirely within their favour, too.

Families, survivors and campaigners were treated with a callousness and disdain that takes the breath away. Only, the Hillsborough campaigners refused to shut up. They wanted answers, and were going to get them, whatever it took.

In the end, 27 years passed before a fresh inquest held in Warrington, Cheshire from 2014-2016, exonerated fans completely and found South Yorkshire Police responsible for the disaster. The jury answered 'yes' to 14 key questions regarding South Yorkshire Police's responsibility. They were in breach of their duty of care. That breach led to 96 people being killed. Those deaths were due to 'gross negligence'. Now, the nation and the world knew 'The Real Truth', as *The Sun*'s tautological headline had put it a few years earlier.

Despite the exoneration of fans after the inquest, the Hillsborough disaster is far from over. The families of the victims now seek and campaign for accountability. The fight for justice and closure goes on until those in charge that fateful day stand in the dock. The 30th anniversary of the Hillsborough disaster is steadily approaching.

'The past is never dead. It isn't even past,' American author William Faulkner once wrote. Hillsborough proves it.



■ Families celebrate at the unanimous verdicts. Liverpool fans did not cause the disaster

IN BRIEF

- **Death toll: 1,836**
- **Eastern United States**
- **23rd August 2005**

Katrina caused widespread destruction along the Gulf coast and plunged most of New Orleans underwater, taking lives and homes and displacing thousands.

HURRICANE KATRINA

When Hurricane Katrina killed 1,800 people and became the most expensive natural disaster in US history, it also blew fresh life into traditional reporting

They were desperate and pleading for help – not for themselves, but for their loved ones and friends. One by one they constructed their messages. "My mother is trapped in her home," typed one; "Marcell is 85yrs old. He is bed ridden and needs to be rescued badly," tapped another. "The town people are trying to get word out that there is no help and people are dying," someone else wrote.

And so it went on. Dozens of messages each day, every single one of them an agonising, individual story that introduced a terrible situation, and yet – just as if the last page of a book had been mercilessly torn out – carried no hint of a potential happy ending or any kind of resolution. But then, they were living in a city of chaos and catastrophe, and being able to even get a message out there was comforting in and of itself.

For this was New Orleans in 2005, and the city was witnessing all of the horrors and heartbreak of one of the worst natural disasters to hit the shores of the United States of America. A population used to turning on the television or seeing a newspaper land on their doormat was suddenly having to find different outlets for information that could so easily be the difference between life and death. Two forms of media suddenly proved their worth: radio and online. It would also become a new chapter for media reporting; a watershed moment during which huge numbers of ordinary people turned to the internet not only to read the news, but to report it themselves.

Jon Donley was the editor of NOLA, a website set up to accompany the *New Orleans Times-Picayune*, a newspaper whose origins in the Louisiana community stretches back to 1837. As Hurricane Katrina made her destructive way across most of the eastern US, he – together with all of the other journalists who worked for the paper – had been busily getting themselves ready for the inevitable spike in stories and coverage such an event would require. Little did Donley know that his website would prove to be so important.

The world had first caught wind of a potential problem shortly after the National Hurricane Centre in Miami, Florida issued its first warning at 5pm on 23rd August 2005. It had noted an interaction between a tropical wave and the remnants of Tropical Depression Ten over the Bahamas, some 350 miles east of Miami, significantly strengthening to that point that it was being labelled a tropical storm the following day.

But by 5pm on 25th August, there was a rising panic. It had become apparent that this was a Category One hurricane, and as winds gusted at around 75 miles per hour and made their way to land, it felled trees and killed two people. Katrina then continued on her path, fluctuating between a tropical storm and a hurricane as the winds lessened and then intensified. They reached 100 miles an hour by the morning of 26th August.

That day, Brendan Loy was sitting on his couch in Indiana with only a laptop computer and the television remote for company. He was a weather enthusiast and blogger who shared his thoughts on his site at irishtrojan.com, and he had spotted something rather concerning. "At the risk of being alarmist," he noted, "We could be 3-4 days away from an unprecedented cataclysm that could kill as many as 100,000 people in New Orleans. If I were in New Orleans, I would seriously consider getting the hell out of Dodge right now, just in case."

He was right to be alarmist. For the next two days, Katrina wreaked havoc. The winds began reaching 175 miles an hour, and the National Hurricane Centre was already suggesting that the people of New Orleans prepare for the worst. Mayor Ray Nagin took no chances, and ordered the city's first ever mandatory evacuation. In a conference, he told residents: "I wish I had better news. This is very serious. This is going to be an unprecedented event." The predictions were terrifying.

The key issue was that New Orleans lies below sea level, and Governor Kathleen Blanco said water was likely to engulf the city, reaching 20 feet in places. The levees that were supposed to protect New Orleans would be unable to provide sufficient protection from the likely rise of the Mississippi River and Lake Ponchartrain. It was imperative that people leave.

But not everyone went. City, state and federal officials, as well as the parish prison's inmates, tourists, hospital patients and media, were allowed to remain. Meanwhile, those too poor to flee were told they could seek refuge in the city's Superdome. It seemed that everything was very much in hand. With all the makings of a juicy story, Donley and the journalists working for the *Times-Picayune* sharpened their pencils, knuckled down and got to work.

The front page on 29th August told of how New Orleans was bracing itself for the "nightmare of the big one", and it wasn't an easy read. Staff writer Gwen Filosa wrote of the stark situation people faced in what was labelled the "last resort". She described homeless men sleeping on the pavements outside, and long queues snaking within the Superdome while people clutched tightly to bedding, toys and other essentials – enough, they hoped, for a few nights, no more.

Elsewhere, the paper reported fears that there would be no electricity or telephone services for weeks or even months. It was believed that at least one half of the city's well-constructed homes would have both roof and wall failure. But that was only part of the tale. The following day, the front page told of what had happened that Monday. 'Catastrophic', said the main headline with other stories below headed, 'Flooding wipes out two communities' and 'After the mighty storm came the rising water'. Katrina had arrived.

For that day, 29th August, New Orleans had become the worst of all the affected areas. The hurricane hit the Gulf Coast with some force, causing damage to the coasts of Mississippi and Alabama, smashing homes apart, sending cars hurtling through the air and bringing down power cables and telecommunications, just as the authorities feared. But it also caused flooding to 80 per cent of New Orleans, and the city was showing signs of stress.

Those sheltering were doing so in the worst of conditions, and as they waited for help, the atmosphere started to turn sour. Food and water became scarce, with the sheer amount of people packed into the massively hot Superdome also finding conditions unhygienic and unsanitary. People were desperate for information and a way of finding missing people. Realising the extent of the problem, local journalists stepped up to the mark and mixed gritty reporting with ingenuity.

But they were not the only ones stepping in to cover the disaster. Bloggers also sought to provide

FACTS

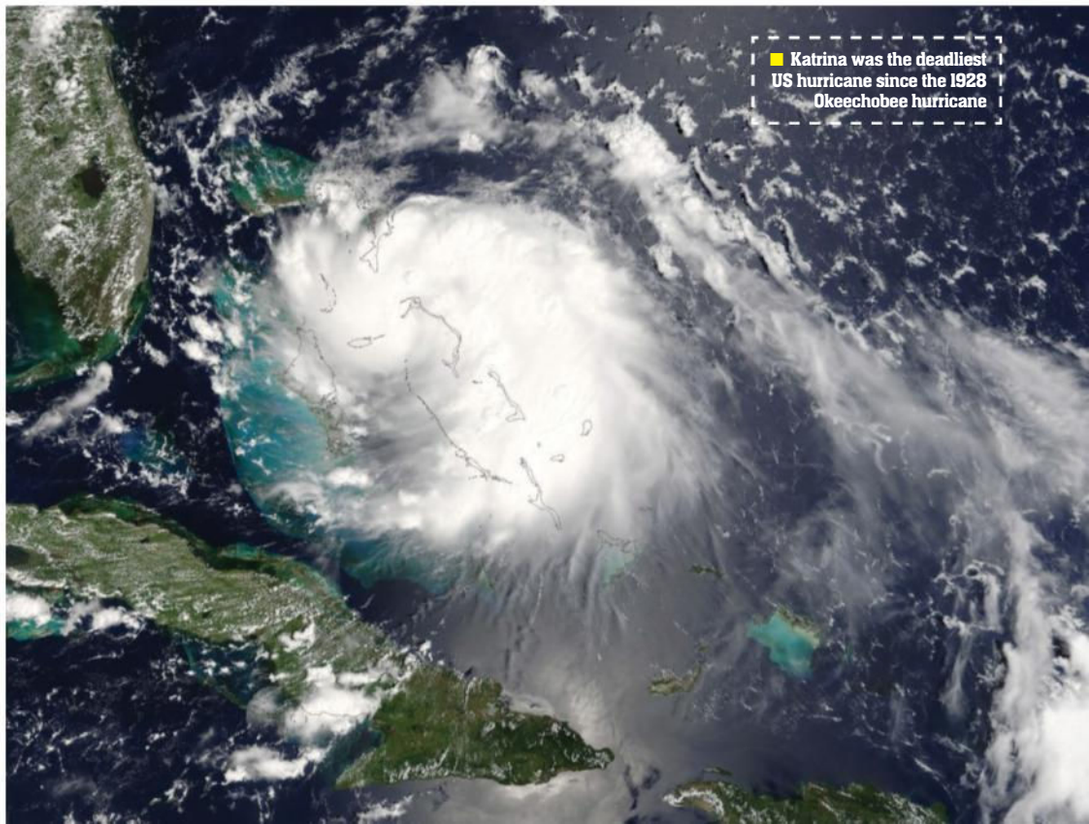
1,836
Number of reported deaths attributed to Hurricane Katrina

53
Number of breaches of the levee system

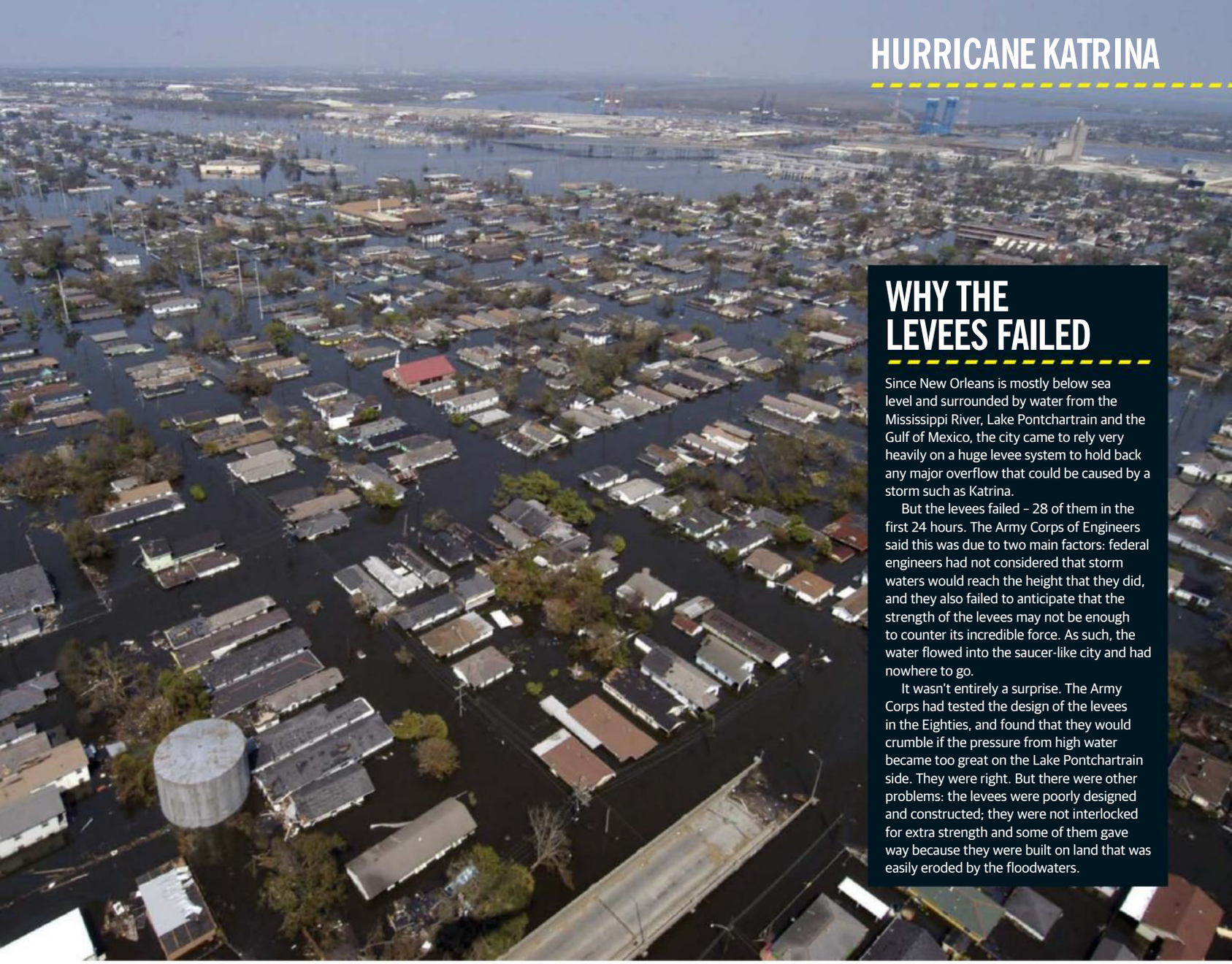
80%
of the city and neighbouring parishes under water

£108 billion
Total amount of damage to property

175
miles-per-hour of the wind at its strongest



■ Katrina was the deadliest US hurricane since the 1928 Okeechobee hurricane



WHY THE LEVEES FAILED

Since New Orleans is mostly below sea level and surrounded by water from the Mississippi River, Lake Pontchartrain and the Gulf of Mexico, the city came to rely very heavily on a huge levee system to hold back any major overflow that could be caused by a storm such as Katrina.

But the levees failed – 28 of them in the first 24 hours. The Army Corps of Engineers said this was due to two main factors: federal engineers had not considered that storm waters would reach the height that they did, and they also failed to anticipate that the strength of the levees may not be enough to counter its incredible force. As such, the water flowed into the saucer-like city and had nowhere to go.

It wasn't entirely a surprise. The Army Corps had tested the design of the levees in the Eighties, and found that they would crumble if the pressure from high water became too great on the Lake Pontchartrain side. They were right. But there were other problems: the levees were poorly designed and constructed; they were not interlocked for extra strength and some of them gave way because they were built on land that was easily eroded by the floodwaters.

reports. Loy's blog became filled with updates as he balanced citizen journalism with his personal life. "I have a job interview in the morning, and classes as well, so I fear I won't be able to blog at quite the furious pace of the past three days," he wrote at, and yet a sense of duty and an ownership meant he was back just three hours later.

Loy used his blog to link to lots of images of the devastation, as well as guest blogs from friends and people who contacted him via his site. But he was by no means alone. Various local bloggers used the New Orleans Metblogs metro blogging site to report on the evacuation and problems, while Kaye Trammell, who was an assistant professor in mass communication at Louisiana State University, made some brief notes of her own. Sites such as deadlykatrina.com or The Weather Channel's own blog complete with streaming video reports became popular, and Weatherblog sought to bring together individual perspectives. Livejournal.com provided a solid platform for many writers, and there were various webcams hoping not to be scuppered by a dropped connection.

"I tend to think that blogging was to Hurricane Katrina what Twitter was to Arab Spring," says Cynthia Joyce, an assistant journalism professor at the University of Mississippi. "It was the perfect tool for the time. In the case of Katrina, blogs wound up providing a real sense of 'place' for many of the displaced. Back then, having an online hub with a permanent web address was so reassuring, especially when your actual home was destroyed or inaccessible."

Not that the professional press wasn't working hard too. The printed *Times-Picayune* had hit problems shortly after 8pm on 29th August when it became apparent that it would be impossible to print and distribute the newspaper the following day. The waters had not only ruined the printing press, but devastated the shops that normally sold it, and so the paper's staff found themselves holed up in a hurricane bunker – the windowless photography department – discussing the need for an alternative. Thankfully, with all of their electricity and broadband intact, the web was able to provide it.

People were already going online in great numbers, and the journalists at the *Times-Picayune* were meeting their readers' needs perfectly, even taking to sleeping in the office, such was their dedication. The NOLA.com news blog soon became the primary way of discovering the latest updates on the hurricane online. Many journalists, regardless of their specialism, were heading out into the city and suburbs to chronicle the damage and personal stories while producing reports with great immediacy.

"Blogging was to Hurricane Katrina what Twitter was to the Arab Spring... blogs wound up providing a sense of place"

Citizens had to resort to desperate measures to save possessions and source edible food and drinkable water

Both they and the bloggers had an advantage over the national media: contacts and familiarity with their areas. The blog structure was allowing them to get under the skin of the city almost in real time, logging the minutest of details, but it worked particularly well because they knew their patch inside out.

"Prior to Hurricane Katrina, New Orleans' anomalies – and, for that matter, those of the entire Gulf Coast – were of little interest to the national media," says Joyce. "In 2005, the network bureau closest to New Orleans was five hours away in Atlanta. Despite this, crews very quickly mobilised to provide 24-7 coverage – some of it stellar, much of it award-winning, but very little of it immediately useful to the victims and evacuees themselves. So the blogs emerged as a critical source of information on a block-by-block, hyperlocal level."

During this time, Donley also made an important decision. He stopped writing his NOLA View blog on NOLA.com, and instead allowed it to become a notice board for others. Readers flocked to it in order to appeal for help finding missing people, with rescuers monitoring it. The blog revealed important information that would save lives, and it helped the site grow quickly from 10 million views on 28 August to 17 million the following day, and 30 million by the end of the week. The staff had to evacuate on 30th August, but they continued to report the news: the paper was simply 'printed' in PDF format and made available online.

There was certainly plenty to write about. By the Friday, a public health emergency had been declared in Louisiana, Mississippi, Alabama and Florida. Food had all but run out in the Superdome and the New Orleans convention centre, and they were certainly proving to be desperate times. In the midst of this, the website was becoming even more vital. Its forums buzzed, and offers of aid flooded in. It would continue that way for many, many weeks.

And yet the websites and blogs weren't the only outlets available. Hundreds of thousands more

THE WRONG KIND OF VICTIM?

CNN's Wolf Blitzer has enjoyed a long and illustrious career, but he made a rather controversial remark following the devastation of Hurricane Katrina: "So many of these people, almost all of them that we see, are so poor, and they are so black," he said. "And this is going to raise lots of questions for people who are watching this story unfold."

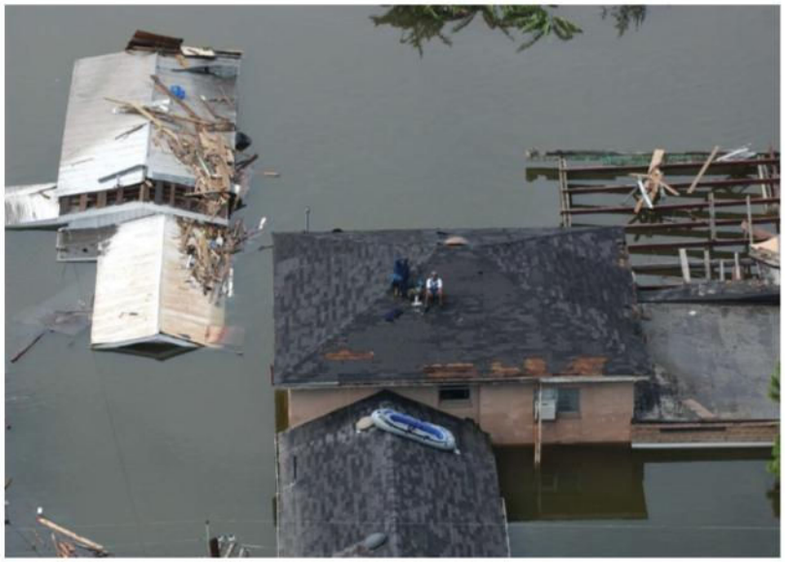
The issue of race in relation to Hurricane Katrina is a sensitive one that has been raised numerous times in the years since the disaster. The response to Katrina is widely seen as having been grossly mismanaged and heavily marked by incompetence and failure. But there is also a prevalent feeling that race may have played a part too.

Many people had been unable to leave New Orleans, with those left behind as the hurricane hit saying they did not have the resources to evacuate. They were told to seek shelter in designated buildings, but the authorities – who appeared to lack leadership and failed to react swiftly enough in enacting effective relief efforts – were ill-prepared for the numbers of people who wanted to use them.

There was a feeling that they had been left to fend for themselves with a distinct lack of provisions. It led to growing opinion that there was an indifference in America to black life, and that had the disaster occurred in a different area with a different racial make-up that the first response would have been far quicker.

Polls following the disaster showed 60 per cent of black people believed race played a part in the slow response, while only 12 per cent of whites felt the same. Many predominantly white commentators said the residents had simply not heeded the warnings – almost blaming them for their situation.

In any case, President George W Bush, who was heavily criticised at the time for not acting quickly enough in response to the catastrophic events in New Orleans, admitted there were "serious problems" in the government's emergency response capabilities. The social consequence of Katrina was a collapse in black racial optimism, and there is no doubt that the disaster has left its mark on the United States in the decade since.



were tuning into the radio too, as one in particular – WWL-AM – came into its own. As one of the few stations on the air in the immediate aftermath of the storm, news anchor and investigative reporter Garland Robinette found himself broadcasting from a makeshift studio, which had been created in a closet at the WWL offices, protecting himself from the gusts that were whistling through the smashed windows.

Listeners hung on to his every word to discover evacuation plans and find out which neighbourhoods were worst affected. The station provided all they needed to know about when help would arrive and what was going to happen in the short term given the sheer number of houses that had been levelled by the power of Katrina. It was becoming increasingly clear that the authorities were not handling the disaster as well as they might, and there was rising anger that little was being done to help them.

On 2nd September, frustration boiled over, and it was heard on WWL. Robinette asked Nagin what he needed. "I need reinforcements, I need troops, I need 500 buses," the mayor replied without

"Nagin had a message for George W Bush: Every day that we delay, people are dying, and they are dying by the hundreds"

hesitation. The frank interview was heard by hundreds of thousands of people, many on the battery-operated radios they had taken with them in their emergency backpacks. The immediacy of the situation was clear.

Nagin expressed anger at talk of getting public school bus drivers to help evacuate: "You've got to be kidding me; this is a national disaster. Get every dog-gone Greyhound bus line in the country and get their asses moving to New Orleans." He had a message for President George W Bush: "Every day that we delay, people are dying, and they are dying by the hundreds I'm willing to bet you."

WWL's rolling news coverage was simulcast on other radio stations, allowing as many people as possible to tune in. It urged people to leave the city, and was boosted by the government's decision to hand supplies that allowed it stay on air during periods of no electricity. By Monday it was the only station broadcasting live.

To get its coverage out to as many people as possible, the radio groups had come together under the banner of The United Radio Broadcasters of New Orleans to simulcast WWL's shows. An estimated 15 stations combined their programming and engineering resources, and a free hotline was set up to allow people to share their eyewitness reports.

The lines became packed with people trying to contact others or share their fear at the rising waters around them, and there was an incredible sense of deja vu as caller after caller related the same scenarios: there was no doubt that people needed to be heard, and there was a sense of duty to report everything that was going on.

"The people of New Orleans are now, more than ever, depending on radio to keep them informed and connected," said David J Field, president and chief executive officer at Entercom Communications, which owns WWL. "Our staff at WWL-AM has provided a vital lifeline of critical news and information to the community throughout the storm and its unfortunate aftermath."

He wasn't wrong. The efforts of the news organisations and the bloggers who provided words, images and videos not only for their own sites, but for newspapers and television channels, helped keep the vital information channels flowing. The same was true in Kentucky, Alabama, Georgi, Ohio, Florida, Mississippi, Louisiana and the other places affected by Katrina. NOLA.com was awarded the Breaking News Pulitzer Prize, and it shared the Public Service Pulitizer with the Biloxi-based *Sun Herald*. It also showed how grass-roots reporting could make a massive difference to relief efforts.

Of course, the problems didn't stop once the storm died down. There was a major relief effort, and a need for repairs and reconstruction. The economic effects were also huge, and the environmental impact was great. There was social disorder to deal with, and the need to draft in thousands of National Guard and federal troops. There was also ongoing criticism of the government's response and of Bush directly. But there was only praise for the tireless local media outlets and the bloggers in helping to make sense of the most chaotic of circumstances. Without them, an unthinkable situation would have been far worse.

VESUVIUS DESTROYS POMPEII

The city that once stood as a bastion of Roman life and culture was savaged by one of the most apocalyptic natural disasters ever witnessed on Earth. This is the story of its dramatic destruction

The darkness that surrounded him was blacker and denser than any night. It smothered like a blanket, choking the sights and the sounds from the air. He had fought it for the people's sake, for her sake, but despite his show of courage to Pomponianus and the others, he knew he couldn't bear it much longer. The sea, his only means of escape from that desolate place of dust and death, remained violent and dangerous, and pinned him to the shoreline mercilessly. The fires grew fiercer, the falling rock heavier and his strength began to fail him. When he closed his eyes, he could still see the flames.

Before the eruption of Mount Vesuvius in 79 CE, Pompeii had long been an important and prosperous settlement. Originally founded by the Oscan peoples of central Italy around the 6th century BCE, it quickly became a crucial economic and cultural hub, with its position between Cumae, Nola and Stabiae placing it at the centre of human activities. The settlement also developed a large and bustling port, with the entire Bay of Naples – as well as destinations further afield – serviced through it. Pompeii was economically and culturally at the centre of Roman life, helping at first to formulate pre-Roman culture and then develop the Roman society that can still be seen in the ruins today.

Although Pompeii is best known for how it met its grisly and spectacular end, it was, for centuries, very much a city teeming with culture and life. This picture of Pompeii as a city is still being pieced together. However, thanks to the diligent work of academics and archaeologists from all around the world, today we are developing a snapshot of what life was like in the city. From a basic point of view, Pompeii boasted almost everything a Roman would expect from a major settlement. Markets, bars, temples, theatres, parks, bath houses, swimming pools, race tracks, vineyards, administrative buildings, blacksmiths, eateries, libraries, schools, armourers, villas and more were all present.

Thanks to excavation work carried out in the city, we know that it sported about 200 bars, for example. Equally, three major bath houses have been unearthed and numerous inscriptions have been found in market halls and other buildings indicating what was sold, bought or exchanged within them. Pompeii was a city of activity and energy that was run from a grand Forum.

The rural areas surrounding the city were also teeming with life and activity. The terrain before the eruption was incredibly fertile, and numerous farmsteads produced vast quantities of agricultural staples such as barley and wheat, as well as olives and more. The city's incredibly prosperous port at the mouth of the Sarno River was also home to many Pompeians. For the time, Pompeii was a rather populous place, with 10-12,000 people living in and around its walls. The city was home to all rungs of society's ladder – the aristocratic rich, the average men and women that worked as merchants, labourers or craftsmen, the children, who attended schools if they could or worked alongside the adults, and of course there were the slaves, an intrinsic staple of Roman society at the time.

IN BRIEF

- **Death toll: est. 2,000**
- **Pompeii, Italy**
- **79 CE**

The eruption of Mt Vesuvius in 79 CE destroyed a city, killed its inhabitants and buried it under ash for centuries. The archaeological remains reveal a profound amount of information.

As the bodies of Pompeians decomposed, ash preserved their form. Models were made by pouring plaster into these voids

Some exceptionally wealthy members of Roman society lived in Pompeii. Archaeologists have found the remains of some truly spectacular residences within the city walls, which at the time would have also had amazing sea views and unparalleled gardens, courtyards and dining halls. One famous residence, titled the House of the Faun, covers three quarters of an acre, while others still contain wondrous mosaics with hundreds of thousands of pieces of stone, or intricately carved statues depicting men, women and deities alike.

Arguably though, it is the discoveries made about the lives of the poor or average people of Pompeii that have been most illuminating. By looking closely at Pompeii's public bath houses, archaeologists have garnered a greater understanding of how they were lit – by hundreds of pottery lamps – and by studying a number of the small shops that lined the city's high street, the Via dell'abbondanza, they have also demonstrated how they used to be protected at night against intrusion with shutters.

The vibrant, everyday lives of Pompeians have also been glimpsed in some of the objects recovered from the city. The now famous 'CAVE CANEM' sign in one of the larger surviving residences translates as 'Beware of the dog', while a series of pictures found in a bar show the kinds of dice games its patrons used to play. Ornate mirrors and combs show the importance some of the wealthier residents of Pompeii placed on their appearance, while records of people, clothing and culture help show that Pompeii was far more multicultural than a typical Roman city.

"Despite all the death and destruction that lies across the city, the Haitian people aren't broken by the disaster"

It is this challenge of discovering the Pompeii that was alive, a city that once stood in the light of the Sun, that currently drives archaeological and academic study in the field. Thanks to the detailed records of Pliny the Younger, the famous Roman lawyer and author, we have a detailed account of Pompeii's fall and the story of how his uncle, Pliny the Elder, strode forth into the disaster zone in an attempt to help the region's fleeing citizens escape. It is with these records that here we are able to imagine what his final hours may have entailed.

Pliny the Elder, a respected military commander of the Roman Empire and formidable natural scientist, was overseeing the region's naval fleet at Misenum across the bay from Pompeii when the letter came. In it, Rectina, a friend of Pliny's, informed him that the mountain's eruptions had rendered all escape from the plains impossible, and pleaded with him as prefect of the naval fleet to come at once to save them.

Pliny, always a man of action and social duty, ordered the fleet's warships to be prepared and launched at once. He had his own doubts about the severity of the situation that Rectina had painted in her letter, but agreed that action must be taken regardless. In contrast, his men were not at all convinced that any movement towards the mountain should be taken. Some said it was a suicide mission, while others feared the wrath of the gods, whose will they believed was being demonstrated through the mountain's eruptions and was something no man was capable of facing up to. Pliny soon dismissed these concerns and, reminding the men that they had a social duty to the people of the region to uphold, ordered that they should make posthaste on a mission of aid.

The fleet launched swiftly and made its course for the bay. As Pliny looked out from the bow of the capital ship, all he could see of the region was that it was cast in permanent shadow under the great cloud of the mountain. The only other detail of note was that the other boats at sea were all heading in the opposite direction. The waters of the bay were choppy but far from unnavigable, and as Pliny surveyed the coastline that was pocketed with poorer settlements and wealthy estates alike, he calculated that they would make land without issue at Stabiae shortly.

Pliny and his fleet soon made port and, amid the falling ash and rock, embraced his friend Pomponianus, who had come to meet him. Interestingly to Pliny, Pomponianus appeared genuinely terrified. He told him of a series of quakes, eruptions and falling debris showers that had plagued the city's residents over the preceding hours, and that numerous other houses had already been damaged. According to the man, the mountain had already destroyed much, and he told Pliny of his fear that his family would be the next to suffer; that their house would fall down and crush them all.

Decamping into Stabiae and, for Pliny, into Pomponianus's residence, the rescue operation

COUNTDOWN TO ARMAGEDDON

For more than 24 hours Vesuvius brought the apocalypse to Pompeii, engulfing the city in flame and ash

24th August, 79 CE

8.00AM
Following more than a week of ground tremors, which were overlooked due to their frequency in Campania, a night of extremely violent shocks occurs that culminates at 8.00am. Many household items and furniture are found overturned.

1.00PM
After a morning of eerie calm, Mount Vesuvius erupts with incredible force, throwing out a cloud of volcanic material that spreads out around the mountain and rises 14 kilometres into the sky. It begins depositing ash over the city.

3.00PM
The volcano continues to throw out volcanic material. As it cools in the Earth's atmosphere, it solidifies and turns into lapilli, hardened lava, which rains down over Pompeii. Most flee the city; some, including the old and pregnant, remain.

4.00PM
Due to the size and intensity of the volcanic hail, Sarno River and the nearby port begin to clog up with debris. Ships get trapped and others at sea cannot make port. Shockwaves shake the city, causing some structures to collapse.

6.00PM
Chunks of pumice (a form of volcanic rock) fall from the volcanic cloud that has now blocked out the Sun. Pompeii's streets are buried under the pumice, lapilli and ash, and buildings are crushed and demolished under the weight.

Most of the second storeys of the buildings in Pompeii were destroyed during the eruption

began. Pliny and his men quickly went about helping the people whose houses had collapsed, who had been trapped by falling masonry or had become separated from their families. They aided people whose carts had become stuck in the ash and rock, helped others to get their bearings amid the chaos and more than once prevented acts of looting, which had begun to take place in some of the shops on the high streets. This was to be Pliny's course of action moving forward. He was going to stabilise Stabiae and then proceed to other towns and cities, such as Pompeii and Herculaneum, aiding those who needed it and maintaining law and order despite the trying conditions.

Pliny awoke the next day in the early hours to much commotion. Against his instruction, the entire house had remained awake all night, with only Pliny getting any sleep. He soon realised that in one way this had been a good thing, as unknown to him, the frequency of the falling rock had increased dramatically and the courtyard from which his room was accessed had almost been entirely filled with rock and debris. In fact, if one of the family had not come and woken Pliny, then he may not have been able to escape the confines of his room. As Pliny moved through the courtyard to bid good morning to the others, the entire house was suddenly subject to a colossal quake, with the walls violently shaking and bits of ceiling crumbling to the ground.

Pliny had already surmised that any further progress on land was then going to be impossible due to the escalating severity of the conditions. He immediately began to plot a new plan in which they would leave as soon as they could via boat, make port further down the bay and redouble their rescue efforts inland. Comparing the risks involved, either being hit by the rock raining down outside or by the falling masonry inside, the assembled group of people decided that they would remain indoors, and there was nothing that would convince them to venture forth with Pliny.

As Pomponianus and company refused to leave the residence, Pliny realised that it would be up to him and his men to get them all to safety. They would have to move quickly, too, as Pliny could see that far from subsiding, the mountain's fury was not yet at its climax. Gathering the best and

25th August, 79 CE

1.00AM
People continue to flee, their movements only occasionally lit up by flashes of lightning. Scalding mudflows stream down the volcano, obliterating the nearby Herculaneum. Ash, lapilli and pumice continue to fall on Pompeii.

4.00AM
The volcanic column that has risen above Vesuvius collapses spectacularly, sending pyroclastic flows (superheated ash and gases) down its slopes. The first of these flows slams into Herculaneum and eradicates all remaining life.

5.00AM
A second, larger and hotter pyroclastic flow buries Herculaneum. In Pompeii, the rain of pumice and ash falters, however, due to the thickness of the ash and gas, it becomes hard to breathe within the city and the surrounding area.

6.30AM
More pyroclastic surges reach Pompeii and demolish the city's northern wall. They sweep over the city in waves of toxic gas and smouldering ash. Everyone still in Pompeii is killed horribly, burned and choked to death.

8.00AM
A final super destructive surge hits Pompeii, demolishing the top floors of almost every building. This surge is so powerful that it reaches Stabiae and even parts of Naples. Fortunately, it loses momentum before it reaches Misenum.

9.00AM
A fire and lightning storm follows, and, after one final eruption, Vesuvius's summit is blasted apart, shearing 200 metres off its top. The cloud begins to clear, but the landscape is changed completely and blanketed in snow-like ash.

bravest of his men, Pliny made for the shore. As they moved, dodging the falling rock and with burning lamps and torches lighting the way left, right and centre (as even after morning arrived the gloom had remained intense due to the mountain's Sun-blocking cloud), Pliny decided that if the conditions were in any way favourable for a launch, then he would gather all he could and leave immediately.

The heat and humidity continued to grow in intensity. The cloud of the mountain seemed, according to Pliny's understanding, to have trapped all of its expelled heat and gas and, combined with the perpetual night and glow of the fires, produced a sweltering and claustrophobic atmosphere. It was at this point that Pliny felt his throat becoming inflamed – an old ailment that had been with him since youth – and he soon found that he was becoming out of breath far quicker than normal.

Upon finally arriving at the shore, Pliny's spirits sunk, as while the wind was not as severe as it once had been, it still blew against a departure and the ocean waves were incredibly fierce. He suddenly felt dizzy and, calling to a few of the men who had made it with him, asked for a blanket to be laid out for him so that he could catch his breath. He also asked, repeatedly, for cold water to be brought for him, which he consumed while sitting on the shoreline and staring out to sea.

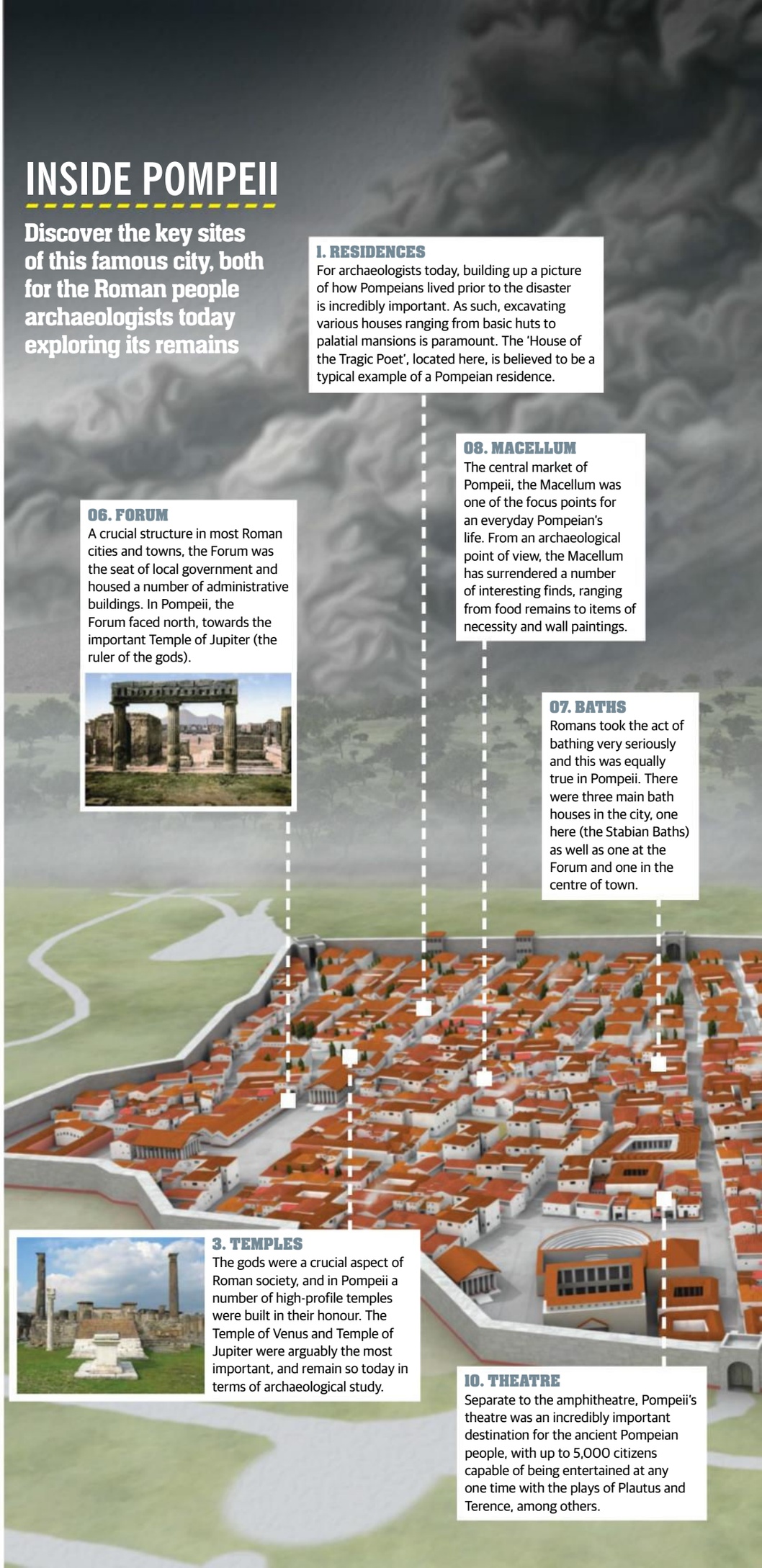
Then, without warning, the glows coming from inland exploded in intensity and the smell of sulphur hit Pliny like a great wave. Looking left and right, he saw the remaining men beginning to flee in every direction, stumbling and tripping in their haste to run. Rising slowly from the blanket, Pliny turned and, like the breaking of the Sun's rays at dawn across the sea, was illuminated by the onrushing firestorm.

Pliny the Elder was found two days later, when daylight finally returned to the region, dead on the shore. His body was found intact and uninjured, looking as though he had slipped into a peaceful sleep. It is believed that he died from suffocation, both due to the density of gases expelled in firestorm and in part to his weak windpipe.

Rectina, who wrote to Pliny, was never rescued and there are no existing records of whether she survived the disaster or not.

The town-cities of Herculaneum, Pompeii and Stabiae were levelled by the eruption of Vesuvius, their populations largely eradicated and their once proud majesty destroyed. However, people soon returned to the region after the disaster and began repairing what they could and rebuilding. Due to the apocalyptic scale of the disaster, though, the three sites were academically lost for more than 1,500 years, with the first new mention of them in historical records emerging in 1599.

Today, the entire region is a major tourist attraction, with millions of visitors seeing this part of Campania every year. It is Pompeii, however, the once thriving centre of culture, that draws the most attention. Its story is one of humanity, both in good times and bad, both in sun and shadow.



INSIDE POMPEII

Discover the key sites of this famous city, both for the Roman people archaeologists today exploring its remains

1. RESIDENCES

For archaeologists today, building up a picture of how Pompeians lived prior to the disaster is incredibly important. As such, excavating various houses ranging from basic huts to palatial mansions is paramount. The 'House of the Tragic Poet', located here, is believed to be a typical example of a Pompeian residence.

08. MACELLUM

The central market of Pompeii, the Macellum was one of the focus points for an everyday Pompeian's life. From an archaeological point of view, the Macellum has surrendered a number of interesting finds, ranging from food remains to items of necessity and wall paintings.

06. FORUM

A crucial structure in most Roman cities and towns, the Forum was the seat of local government and housed a number of administrative buildings. In Pompeii, the Forum faced north, towards the important Temple of Jupiter (the ruler of the gods).

07. BATHS

Romans took the act of bathing very seriously and this was equally true in Pompeii. There were three main bath houses in the city, one here (the Stabian Baths) as well as one at the Forum and one in the centre of town.

3. TEMPLES

The gods were a crucial aspect of Roman society, and in Pompeii a number of high-profile temples were built in their honour. The Temple of Venus and Temple of Jupiter were arguably the most important, and remain so today in terms of archaeological study.

10. THEATRE

Separate to the amphitheatre, Pompeii's theatre was an incredibly important destination for the ancient Pompeian people, with up to 5,000 citizens capable of being entertained at any one time with the plays of Plautus and Terence, among others.

9. AMPHITHEATRE

Another serious pastime for Ancient Roman citizens was going to watch combative sports at the amphitheatre. Everything from gladiatorial fights and chariot races to executions were staged in this impressive arena. Today, concerts and public events are held at the venue.

2. HIGH STREET

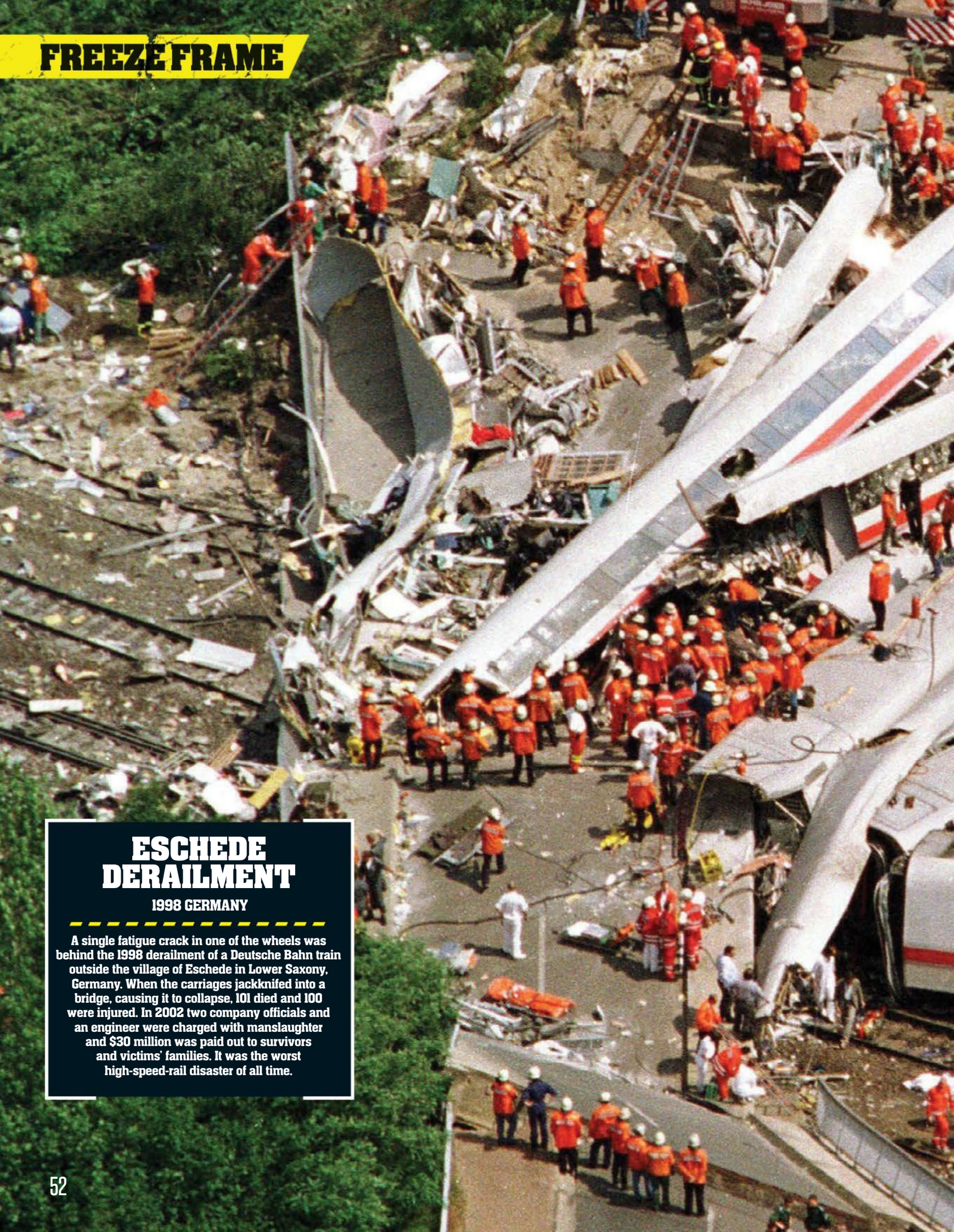
Pompeii was intersected in an east to west orientation by the Via dell'abbondanza, a large high street off which a number of merchants, bars, baths, administrative buildings, temples and more were located and connected.

05. PALAESTRA

Another important site for Pompeians was the Palaestra, a large grassy area equipped with a swimming pool and surrounded by a portico. The site was used as an exercise ground for the local people, as well as for military training.

04. BARS

Unsurprisingly, bars were an incredibly important part of Pompeian life. Archaeologists have discovered the remains of more than 200 bars in Pompeii, with many lining a vast vineyard boarding the Via dell'abbondanza high street.



ESCHEDE DERAILMENT

1998 GERMANY

A single fatigue crack in one of the wheels was behind the 1998 derailment of a Deutsche Bahn train outside the village of Eschede in Lower Saxony, Germany. When the carriages jackknifed into a bridge, causing it to collapse, 101 died and 100 were injured. In 2002 two company officials and an engineer were charged with manslaughter and $30 million was paid out to survivors and victims' families. It was the worst high-speed-rail disaster of all time.


ICE
DB

SPACE SHUTTLE CHALLENGER

Mismanagement and incompetence caused one of the worst accidents in the history of spaceflight

"Uh oh." Those were the chilling final words of Pilot Michael Smith, and the final transmission from the Space Shuttle Challenger. It will never be known what was going through Smith's head as he uttered those two words. Because a split second later, the vehicle exploded, leading to the deaths of all seven astronauts on board. How and why this happened is a complex story laden with mismanagement, misfortune and, ultimately, tragedy.

The story of Challenger begins long before its final flight on 28th January 1986. In fact, you can essentially trace it back to the start of the Space Shuttle programme. When the Space Shuttle was first dreamed up in the 1970s, it was unlike anything in space exploration that had come before. Previously, spacecraft had taken the form of capsules launched to space on a rocket, and then parachuted back to Earth at the end of the mission. This was tried, tested, and, for the most part, safe. But space travel was and remains expensive, so in an effort to reduce costs (and also capabilities), NASA envisioned having a space plane that could fly regularly to orbit and back. While the finished product wasn't quite the space planes of *2001: A Space Odyssey*, it was still mightily impressive, albeit without reducing costs by as much as hoped due to the high cost of refurbishment after each mission.

With this increased capability came the prospect that space travel might not just be the reserve of professional astronauts any more. The Space Shuttle could seat seven people, but not all were needed to operate the vehicle; two could be 'payload specialists', people of other professions such as scientists, or even more general members of the public such as writers that could travel to space.

This Challenger mission, STS-51-L, was to be the 25th Space Shuttle mission since the first in April 1981. This launch rate itself was remarkable, but also showed a confidence in the vehicle, with several launches every year. As such, in 1984, President Ronald Reagan announced the Teacher in Space Project (TISP), which would start taking teachers on Space Shuttle missions as payload specialists. This was a completely new area for NASA, and indeed any space agency.

11,000 teachers applied for the coveted first slot, which would be aboard STS-51-L. After being whittled down to ten, one candidate emerged as the frontrunner thanks partly to her unbounded enthusiasm: Christa McAuliffe, a social studies teacher from Concord High School, New Hampshire. McAuliffe was scheduled to do a large amount of public outreach during her two weeks in orbit, including two 15-minute lessons to 2 million schoolchildren in the US, among other activities.

"I'm still kind of floating," she said at a press event after her selection. "I don't know when I'll come down to Earth."

With McAuliffe picked, preparation for the mission was well under way. At a time when public interest in the Space Shuttle programme was dwindling, NASA hoped she would re-invigorate a public infatuation with the costly vehicle. Together with proving that it was safe and reliable, some have said that NASA had a case of "launch fever" at the time of the Challenger mission in question. That is, they wanted to launch their Space Shuttles as quickly and as often as possible. It is perhaps for this reason, then, that problems with the launch of Challenger arose.

When the Space Shuttle was first being developed in the 1970s, an early potential problem was discovered. To launch, the Shuttle was first attached to a main tank, with two Solid Rocket Boosters (SRBs) either side. Each of these was made of seven sections, six of which were joined

IN BRIEF

- **Death toll: 7**
- **Atlantic Ocean, Florida**
- **28th January 1986**

Challenger exploded 73 seconds into its flight, killing all seven crew on board. It was NASA's first in-flight launch disaster and highlighted that, while space travel was longed for by many, it was still an incredibly risky business.

WHAT THE MISSION WOULD HAVE DONE

During its seven days in space, Challenger had a number of goals it would have completed had the launch been successful.

Its main goal was to launch the second Tracking and Data Relay Satellite (TDRS-B), used by the US government and other agencies to communicate with things like satellites, and later the International Space Station.

A small satellite on board, the Spartan Halley spacecraft, would have flown free from the Shuttle for two days to observe Halley's Comet as it made its closest approach to the Sun.

On the second day, Christa McAuliffe would have begun the first teacher in space video taping, with further live telecasts planned for the fourth day.

One member of the crew, Ronald McNair, was even planning to play the saxophone in space, performing a piece of music he worked on with composer Jean Michel Jarre for his album *Rendez-Vous*.

The seventh day would have been Challenger's triumphant return to Earth, after 144 hours and 34 minutes in space. Sadly, that never came to pass.

FACTS

73 Seconds after launch, Challenger exploded.

9 Successful flights of the Challenger Space Shuttle.

7 Number of people lost in the accident

995 orbits Challenger completed prior to this mission

25.8 million miles Cumulative distance travelled by Challenger on previous missions

121,778KG Weight of Challenger on its final flight

In this image above, the plume that led to the explosion can be seen developing

together and sealed with rubber 'O-rings', circular rings measuring 11.6 metres in diameter.

Utah-based manufacturing company Morton Thiokol was behind the construction of the SRBs, but in early testing they found a potential problem with the O-rings. In some specific tests, the metal of the SRB could bend and open, allowing hot gas to escape through the seal made by the O-rings. If serious, this could result in something called 'burnthrough', where hot gases escape and, ultimately, cause a structural failure of the SRBs. In other words, an explosion. That the seal of the O-rings could open was known, but the seriousness of the problem was not fully realised.

The Space Shuttle itself was also lacking a proper launch abort system. For previous manned rockets with capsules, this system composed of a spike with thrusters attached to the top of the rocket. In the case of an emergency, the capsule could be carried to safety before the rocket exploded. NASA had never had a need for this system on any of its previous manned flights.

On the Space Shuttle, though, the entire crew were housed inside a cabin, much like a plane. With seven crew across two decks, there was no way to eject everyone in the case of a catastrophic failure. There had been some talk in development of creating a detachable crew cabin, but this proved too difficult, most notably with adding too much mass to the entire vehicle.

This meant there was no feasible way to get a crew to safety during a Shuttle launch. Following the Challenger disaster, things changed. The crew were provided with parachutes and, in the event of an emergency after launch, the pilot would attempt to get the Space Shuttle into a controlled glide. Each crew member would then jump out via a hatch with explosive bolts, shimmying down a pole to make sure they missed the wing when they jumped. This launch abort system was never used, and at any rate, the SRBs could not be stopped once they were ignited. This meant that to get the Space Shuttle into such a glide, the pilot would have to wait for the SRBs to expend all their fuel after about two minutes. Thus, this method would not have saved the crew of Challenger, who likely died upon impact with the Atlantic.

All of this leads us to the events on the fateful day of Tuesday 28th January. This mission had huge public attention, notably because of McAuliffe on board; it's estimated that 17 per cent of Americans watched it live, and 85 per cent knew of the accident within an hour after it occurred.

Leading up to the launch, STS-51-L was already dogged by delays. Scheduled to launch on 22nd January, it had been pushed back to the following day, and then the next, due to delays with the previous mission, Space Shuttle Columbia on STS-61-C. Further delays arose because of bad weather in Dakar, Senegal, where the Space Shuttle could land in an emergency mid-flight. These factors pushed the flight back to 28th January.

"The launch feeds, live on TV, showed this plume at 58 seconds after launch, although it's unlikely many knew its significance"

All Space Shuttles launched from the famous Kennedy Space Center Launch Complex 39 at Cape Canaveral in Florida. The site is useful for its proximity to the equator (giving launches a bigger speed boost from Earth's rotation), and also having an east-facing coast over an ocean. This allows parts (such as SRBs) to be discarded in the ocean after launch. But Florida is also known for its changeable weather, and on the morning of the launch, temperatures dropped to below freezing at -2.2 degrees Celsius. The previous coldest launch had been 12 degrees Celsius.

Engineers at Morton Thiokol warned NASA that the rubber seals, the O-rings, wouldn't seal properly at temperatures this low. One Rob Ebeling, was particularly forthcoming in his views. NASA, however, were staunchly opposed to a delay; after all, the Space Shuttle was already grossly behind schedule.

An astonishing exchange then occurred. Thiokol management had told NASA they should delay the launch but, in a conference call, NASA's George Hardy, manager of the SRB project, said: "I am appalled. I am appalled by your recommendation." This was recollected many years later by Roger Boisjoly, another engineer at Thiokol, as reported by NPR. Another Shuttle program manager, Lawrence Mulloy, added: "My God, Thiokol. When do you want me to launch, next April?"

Incredibly, despite these concerns, NASA pressed ahead with the launch. Then, for reasons

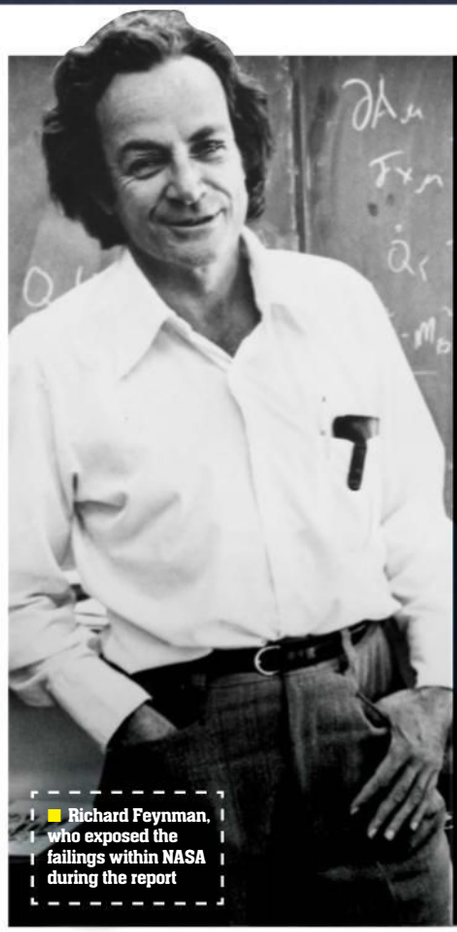
unknown, Thiokol management reversed their original view and said the launch should go ahead.

Ebeling was particularly shocked. He told his wife Darlene that night before the launch, "It's going to blow up," reported NPR. Later, in an interview in 2016, he said heartbreakingly: "I think that was one of the mistakes that God made. He shouldn't have picked me for the job. But next time I talk to him, I'm gonna ask him, 'Why me. You picked a loser.'"

So, in the morning, launch preparations went ahead. A huge amount of ice had built up on the rocket, raising more concerns about the SRBs. Launch was delayed by an hour but, as the ice appeared to be melting, the decision was made to go ahead. At 11.38am EST, Challenger launched.

Just two seconds after launching, things started to go wrong. Almost immediately, the O-rings failed, but a piece of solid fuel created a temporary seal. Amazingly, this may have been the only thing to prevent the Shuttle exploding immediately on the launch pad. Challenger climbed higher into the sky, and the launch appeared to be going as planned. "Liftoff of the 25th Space Shuttle mission," NASA television commentator Hugh Harris said.

But 36 seconds after launching, Challenger experienced a huge blast of wind, a wind shear, pushing it sideways. The on-board computers compensated for this motion, but in doing so,



Richard Feynman, who exposed the failings within NASA during the report

ROGERS COMMISSION REPORT

Almost as infamous as the Challenger disaster itself were the circumstances surrounding the investigation into why it occurred. Under the orders of President Ronald Reagan, a commission was set up to determine the cause of the disaster. Among its many members were some high-profile names, including Neil Armstrong and Sally Ride. One name would later attract the most attention, though: Richard Feynman, an American theoretical physicist.

The investigation came to the conclusion that the accident was caused by the failure of the O-rings in creating a seal in the SRBs due to a flawed design. "The Commission has concluded that neither Thiokol nor NASA responded adequately to internal warnings about the faulty seal design," the report would ultimately conclude.

Feynman, though, led his own investigation, delving into the inner workings of NASA itself. What he found was a gross disconnect between the engineers and management.

One of his most startling finds was the expected failure rate of the Space Shuttle. NASA management told him there was a one in 100,000 chance of a catastrophic malfunction, but it soon became clear this number was all but plucked from the air. When he asked the engineers to anonymously estimate their own odds of failure, their numbers were mostly between one in 50 and one in 200. Most famously, Feynman performed a makeshift experiment on O-rings during a televised hearing, putting one in a cup of ice.

His style was not liked by other members, and his findings were confined to a minority report within the main report.

dislodged the piece of solid rocket fuel. This wind shear is thought to have been the largest ever experienced on a Shuttle launch and, tragically, had it not occurred, there's every chance the mission may have succeeded.

That, sadly, was not the case. Having throttled down the engines while passing through the wind shear, Challenger now throttled up as it continued its climb towards space, at about 51 seconds after launch. At 58 seconds, a flame flickered into life in a joint on the right-hand SRB, where one of the O-rings had failed. In half a second, this developed into a visible plume.

The launch feeds, live on TV, showed this plume at 58 seconds after launch, although it's unlikely many knew its significance. The flame began to burn onto the SRB itself, burning through the joint that attached it to the main tank. Those in mission control were equally unaware. At 68 seconds, the capsule communicator for the mission - astronaut Dick Covey - gave a standard call to increase the power of the Shuttle's main engines. "Go at throttle up," he said. "Roger, go at throttle up," Commander Dick Scobee on board Challenger responded.

The result was almost instantaneous. At 72 seconds, the flame burned through the struts holding the right SRB to the main tank. It pivoted around its upper strut, hitting the main tank. At 73 seconds after launch, disaster struck.

In a split second, the external tank split. There was not an explosion as such, but more of a violent breakup and fire. The resultant force split Challenger into pieces, while the SRBs, more sturdily built, flew away from the explosion in uncontrolled flight. By 78 seconds, the air was filled with a huge cloud of fire, smoke, and propellant. Pieces of the Shuttle were flung in all directions. The iconic image of the Challenger explosion is one few will forget.

One cause for contention, though, regards when the astronauts actually died. At the time,

Ice on the Shuttle on the morning of the launch, showing how cold it was

NASA's official line was that they were knocked unconscious or killed by the blast, and remained so until their cabin plunged into the ocean, killing them all instantly. However some experts, and an exhaustive story from reporter Dennis E Powell in the *Miami Herald*'s *Tropic* magazine, have suggested that the crew survived and were conscious through the whole event until the ocean impact. With no means of escape, they would have been trapped inside the crew cabin for two minutes and 45 seconds as it plummeted to the sea, eventually impacting at 333 kilometres per hour and killing all seven.

Later reconnaissance done at the bottom of the Atlantic Ocean, where Challenger's cabin came to rest, revealed that some of the astronauts had turned on their oxygen masks, suggesting they had indeed survived the initial fire and breakup. It's unlikely we'll ever be sure exactly when they died. Salvage crews brought up the remains of the astronauts; those that could be identified were given to their families, and the rest buried at Arlington National Cemetery in Virginia in a monument to the crew.

Immediately after the accident, engineers and mission controllers had the grim task of poring through the data, to find out what went wrong. It wouldn't be until the Rogers Commission Report that the fault - that of the O-rings - became widely known. In fact, early reports said that destruction charges on the external tank had been detonated by mistake - although the salvage operation proved this not to be the case.

President Ronald Reagan gave an address from the Oval Office after the disaster. "We've grown used to wonders in this century," he said. "It's hard to dazzle us. But for 25 years the United States space program has been doing just that. We've grown used to the idea of space, and, perhaps we forget that we've only just begun. We're still pioneers. They, the members of the Challenger crew, were pioneers."

The Space Shuttle would not fly again until 29th September 1988, when the Discovery launched on a "Return to Flight" mission. The program would continue successfully until 2003, when another disaster - that of Columbia - again rocked NASA.

Aside from the Shuttle being grounded, NASA also had issues with contractors who wanted their satellites to be launched on the Shuttle. Some asked to use other rockets in NASA's fleet, such as the Titan rocket. NASA's policy towards the media, too, has changed drastically since. Members of the press were denied information in the early days after the accident; today, the agency is much more open towards the media.

The Challenger disaster was a dark day in the history of spaceflight. It remains a shadow over NASA, and perhaps plays some part in why the agency is so cautious with its human space flight endeavours today. The Space Shuttle program was ended in July 2011, but the crew of Challenger will live long in the memory.

THE AFTERMATH OF CHALLENGER

The Challenger disaster rocked NASA to its core. The Space Shuttle programme was grounded for 32 months, during which the Rogers Commission Report took place. For the agency, it was a time to re-evaluate the Shuttle program.

The SRBs were redesigned to prevent such a problem happening again. The joints were strengthened by adding an additional O-ring, while much better monitoring of temperature was initiated to ensure no materials were affected by changeable conditions.

From a public-relations point of view, the Challenger disaster put NASA's plans to make space travel achievable for civilians on hold, with Christa McAuliffe dying in the accident. Originally, it had been planned to have a journalist follow McAuliffe a year later, and then an artist. Ultimately, anyone could have flown.

According to *Smithsonian Magazine*, a NASA-appointed task force in 1983 remarked that, "It is desirable for NASA to fly observers on the shuttle for the purpose of adding to the public's understanding of space flight." One NASA spokesperson even thought they'd have 3 million applicants if they opened the opportunity to the public, with a lottery on the cards as a way to decide who got to fly. Even Big Bird, of Sesame Street fame, was considered by NASA as an option, alongside writers who could pen wonderful prose about the experience.

In fact, two weeks before the Challenger disaster, more than 1,700 journalists had applied to go on a subsequent Space Shuttle mission. Following the accident, no journalist ever flew.

The backup to McAuliffe, Barbara Morgan, did eventually fly on a Space Shuttle, Endeavour, in 2007. But the Challenger disaster ended the dream that the Shuttle might be the spacecraft for the people. Nowadays, we look to private companies like SpaceX and Blue Origin for that same inspiration.

"With no means of escape, they would have been trapped inside the crew cabin for two minutes and 45 seconds as it plummeted to the sea"

THE CREW

DICK SCOBEE

46-year-old Francis Richard 'Dick' Scobee was the commander of the Challenger mission. Born on 19th May 1939 in Washington, he joined the US Air Force in 1957, and the NASA Astronaut Corps in 1978.

MICHAEL SMITH

The pilot on the Shuttle was Michael J Smith, who died at the age of 40. He was born in Beaufort, North Carolina, on 30th April 1945. He served in Vietnam for the US Navy, and joined NASA in May 1980.

ELLISON ONIZUKA

Mission Specialist Ellison Shoji Onizuka was the first Asian American to launch to space, and also the first of Japanese ancestry. He was born on 24th June 1946 in Kealakekua, Hawaii, and served in the US Air Force. He died at the age of 39.

JUDITH RESNIK

36-year-old Mission Specialist Judith Resnik was to become the second American woman in space after Sally Ride. Born in Akron, Ohio, on 5th April 1949, she was a biomedical engineer and systems engineer before joining NASA in 1978.

RONALD MCNAIR

Born in South Carolina on 21th October 1950, Mission Specialist Robert Evander McNair, 35, was a physicist before he joined NASA in 1978. He flew on one mission prior to the disaster, in 1984, also on Challenger.

GREGORY JARVIS

Payload Specialist Gregory Bruce Jarvis was born on 24th August 1944 in Detroit, Michigan. Jarvis was an engineer, despite a four-year stint in the US Air Force, and was selected as a candidate payload specialist in July 1984. He died at 41.

CHRISTA MCAULIFFE

Payload Specialist Sharon Christa McAuliffe was born on 2nd September 1948. She was to be the first teacher in space as part of NASA's flagship Teacher in Space Project (TISP), selected in 1985. She died at the age of 37.

THE BLACK DEATH

The terrifying true story of the outbreak that crippled the world

IN BRIEF

- **Death toll: 75-200 million**
- **Worldwide**
- **1346-1353 (European peak)**

Europe's population fell by 30-60 per cent and took three centuries to recover. Spread by rats, symptoms included, fever, vomiting, respiratory problems and boils in the armpit and groin.

THE BLACK DEATH

After enjoying generations of sunshine and warmer climes, Europe had undergone an unprecedented population boom that saw more people living on the continent than ever before. At the turn of the first millennium there were 24 million people in Europe, and by 1340 this had reached 54 million.

Entire countries were straining at the edges of their farmlands and eating into the forests, and the availability of food was beginning to reach the limits of population support. A dire evil, however, stalked the land, just as the Little Ice Age began, and a century later Europe's population had plummeted to 37 million.

The true origins of this bringer of death are unknown, though many people believe it emerged in south-east Africa centuries ago and crept along the Nile to the Eurasian continent. This monster scurried on a million legs through the dank holds of ships, grain-stuffed silos and mills, filthy streets and docks slick with grime – and much worse in the years to come.

It sprang from the backs of great black rats, borne in the blood of fleas infected with *Yersinia pestis*, and thrived in the blood-flecked sputum of the plague's violently coughing victims. It wept from the bulbous, stinking sores that erupted in people's groins and armpits. It struck fiercely and mercilessly, bringing down towns in a matter of days, erasing families in mere hours.

While we now call this great pandemic that swiftly brought Europe to its knees in the mid-14th century the Black Death, it was known by a different name at the time – the apocalyptic moniker, Pestilence. With the Hundred Years' War sweeping western Europe and conflicts with the unstoppable Mongolian Golden Horde in the east, famine beginning to crippling countries whose populations were at the limits of sustainability, and then sickness swiftly following – bringing with it death – the people of the world knew that Pestilence was upon them, and many feared the apocalypse drew near...

Pestilence is shrouded in mystery, and even now researchers still debate the exact components of the beast and the path it took across the continent. What is certain is that it originated in the eastern end of the continent, and worked its way through the Mongolian Empire before piercing Caffa (now Feodosiya in Ukraine), Sicily and southern Europe, reaching peak strength as it smashed into France and England.

Scientists agree that its main weapon was bubonic plague, a bacterial disease carried by infected fleas that fed on the black rats ubiquitous to the continent, but were also known to dine on other types of rodents, rabbits and, sometimes, larger mammals like cats.

The bacterium itself – *Yersinia pestis* – was a rather nasty piece of work; it would infect the blood of fleas and then cause a buildup of old

blood and cells within the proventriculus (a valve preceding the flea's stomach). This blockage meant that when a hungry flea tried to bite its next victim, the high pressure in its stomach would force some of the ingested blood back into the open wound, along with thousands of bacterial cells that had accumulated in the proventriculus.

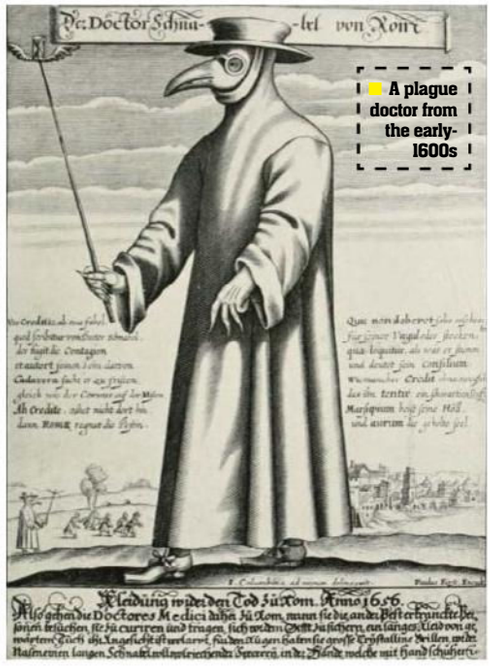
This swarm of *Yersinia pestis* would then drain along the lymphatic tract of the victim from the source of the bite down to the nearest lymph node. Once there, the bacteria would proceed to colonise the lymph node so entirely that it would swell, stiffen and ooze a rancid pus. Since most people were bitten on their legs, this would usually be the lymph node in the groin. These enlarged lymph nodes, known as buboes, were the main sign of Pestilence; ugly and painful, they ranged from the size of a grape to a fat orange and they made any movement unbearable.

Before the appearance of the buboes though, victims would have a slight warning. Flu-like symptoms would appear first, swiftly followed by a high fever. Within a day or two these would be joined by 'God's tokens' – small circular rashes, also called roses – that would spread over the body and particularly around infected lymph nodes. Caused by weak blood vessel walls and internal haemorrhaging, they were a sure sign that you didn't just have a nasty cold, as noted by Shakespeare: 'the tokened pestilence where death is sure'. Things tended to move quickly once the buboes had boiled up through the skin. Diarrhoea and vomiting would ensue, as would often septic shock due to the buboes bursting, with respiratory failure and pneumonia wiping up the last sops of life. Within two weeks, four out of five people who contracted the plague died.

Agnolo di Tura del Grasso, a chronicler from Siena, Italy, captured the terror of the time well: 'I do not know where to begin describing its relentless cruelty; almost everyone who witnessed it seemed stupefied by grief. It is not possible for the human tongue to recount such a horrible thing, and those who did not see such horrors can well be called blessed. They died almost immediately; they would swell up under the armpits and in the groin and drop dead while talking. Fathers abandoned their children, wives left their husbands, brothers forsook each other; all fled from each other because it seemed that the disease could be passed on by breath and sight. And so they died, and one could not find people to carry out burials for money or friendship.'

"It was a staggering loss in this age of arable farming, where the majority of the country's wealth lay in the land"

In the face of Pestilence and the approaching end-times, King Philip VI of France commissioned the Faculty of Medicine at the University of Paris to deduce the source of the evil so that it might be eradicated. The findings of these professors did not bode well, for they ascribed the tragedy to the conjunction of Saturn, Mars and Jupiter in Aquarius, and to the position of Saturn in the House of Jupiter – and nothing could be done to challenge the will of the cosmos. At the time, Jupiter was believed to be the source of warm, humid vapours, while hot, dry Mars was thought to ignite them. These pestilential vapours were thought to form a thick, stinking smog of sickness known as a miasma, which was compounded by the sulphurous eruptions of volcanoes and wrathful power of earthquakes.



A plague doctor from the early-1600s

Believed to be the main culprit of the Black Death, people gave up bathing (as it opened the pores to miasma), barricaded themselves in closed rooms hung with thick tapestries to block out the poisoned air and took to carrying nosegays and pomanders to avail themselves of the evil stench. None of this would save them though.

In 1346, amid reports from the east of biblical plagues – rains of frogs and serpents, hail, stinking smoke and thunder – the Mongols of the Golden Horde attacked Caffa – an island port off the north coast of the Black Sea. The horde laid siege to the city and were all set for a protracted campaign when the Black Death struck them in the back ranks. Suddenly, their army was dying and the siege began to fall apart. What followed is the first known incidence of biological warfare: about to pull back and return to the east, the horde first gathered up the diseased bodies of their dead and catapulted them over the walls of Caffa.

Instantly, Pestilence struck Europe, and though it took around 15 years to cross Asia it would destroy Europe in less than five. As the horde went home, defeated, the Black Death ran around the coast of the Black Sea and straight through the Byzantine Empire (south of modern Bulgaria). By 1347 – just as Joan of England, of the House Plantagenet, was departing Britain to marry Prince Pedro of Castile and form a political alliance – it had arrived on the Mediterranean and struck Messina in Sicily. Here, frightened peasants were beginning to realise that the monster attacked by sea and had started to refuse ships at the port, but it was a case of too little, too late.

Trading ships from Genova and Constantinople carried the plague to the Italian mainland, where it ran up and down the infected rivers, canals and walkways. By 1348, 600 people were dying each day in Venice; Rhodes, Cyprus and Messina had all fallen. The invasion gathered pace and then punched up into the heart of Europe, striking down 60 per cent of Marseille's population and half of

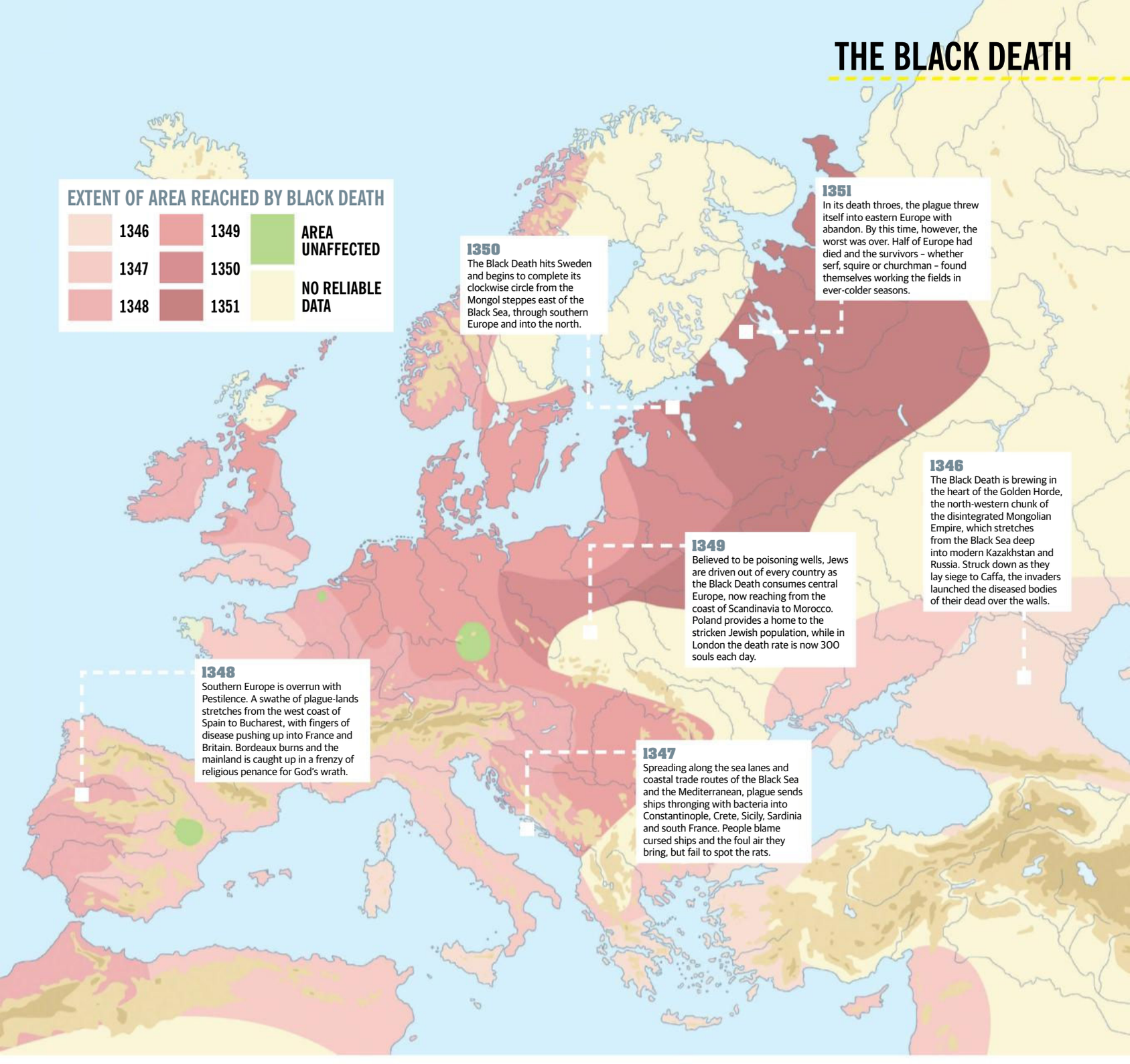
KILL OR CURE

A number of herbal treatments were thought to be effective against the Black Death. Sufferers were regularly prescribed, depending on their income, solutions of ground emeralds or potions made from the crushed shells of newly laid eggs mixed with chopped marigolds, ale and treacle. Another effective curative was urine – two glasses a day was thought to fend off disease.

Treatment of the buboes was a trickier affair. In their terror, people believed they could draw out Pestilence by holding bread against the boils and burying it – or, more incredibly, by strapping a live hen to the swelling, rinsing and repeating. Physicians later discovered that lancing buboes, draining the pus and applying poultices was relatively effective in the early stages. Such poultices usually consisted of tree resin, white lily root and then dried human excrement, arsenic or dried toad, depending on availability. Less extreme ointments were mixed from cooked onions, butter and garlic, while bloodletting through leeches or incisions and the application of clay and violets was also practised.

For the most part, since the Black Death was allegedly miasmatic, the best preventative measure was thought to be carrying pouches of sweet herbs and spices (or balls of perfume called pomanders), and burning them in your home. Most felt their only options were to fast, pray and join the Flagellants to pay penance for their sins, or to kill suspected witches.

THE BLACK DEATH



1351
In its death throes, the plague threw itself into eastern Europe with abandon. By this time, however, the worst was over. Half of Europe had died and the survivors – whether serf, squire or churchman – found themselves working the fields in ever-colder seasons.

1350
The Black Death hits Sweden and begins to complete its clockwise circle from the Mongol steppes east of the Black Sea, through southern Europe and into the north.

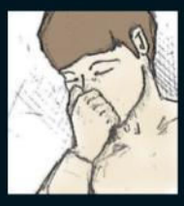
1346
The Black Death is brewing in the heart of the Golden Horde, the north-western chunk of the disintegrated Mongolian Empire, which stretches from the Black Sea deep into modern Kazakhstan and Russia. Struck down as they lay siege to Caffa, the invaders launched the diseased bodies of their dead over the walls.

1349
Believed to be poisoning wells, Jews are driven out of every country as the Black Death consumes central Europe, now reaching from the coast of Scandinavia to Morocco. Poland provides a home to the stricken Jewish population, while in London the death rate is now 300 souls each day.

1348
Southern Europe is overrun with Pestilence. A swathe of plague-lands stretches from the west coast of Spain to Bucharest, with fingers of disease pushing up into France and Britain. Bordeaux burns and the mainland is caught up in a frenzy of religious penance for God's wrath.

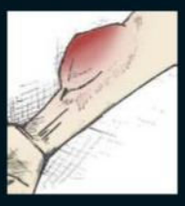
1347
Spreading along the sea lanes and coastal trade routes of the Black Sea and the Mediterranean, plague sends ships thronging with bacteria into Constantinople, Crete, Sicily, Sardinia and south France. People blame cursed ships and the foul air they bring, but fail to spot the rats.

WHEN PESTILENCE STRIKES...



FLU HITS
The Black Death begins like a bad cold, with aches, pains, chills and a fever setting in.

GOD'S TOKENS
Just a few hours later, circular red rashes begin to appear around infected lymph nodes.



BUBO BREAKOUT
Within a day or two, the lymph nodes blacken and swell almost to the size of oranges.

VOMITING
Severe fluid loss, including blood, accompanies and exacerbates all the bloating buboes.

SEPTIC SHOCK
Two to three days after infection, septic shock and pneumonia often hit the victim.

RESPIRATORY FAILURE
Weakened under the assault, the body's central systems begin to shut down.

DEATH
Usually within two to four days, Pestilence conquers the host. Many dead were left in the street.

Paris's. The bewildering death toll was so high that the mayor of Bordeaux even set fire to the port, in a remarkably prescient move considering the fact that serpents and smog were more feared than rats at this stage.

Britain fared little better at the time. Arriving on the south coast of England in 1348 – primarily through ports like Bristol, Weymouth and London – the Black Death was to claim 50 per cent of the population and reach a height of around 300 souls each day in London by spring 1349.

It was a staggering loss in this age of arable farming, where the majority of the country's wealth lay in the land. Acres and acres of golden cornfields were left without farmers to sow or plough them; knights and churchmen subsequently found themselves working in fields by the sweat of their brows – and this led to the growth of the new yeoman class, as serf-less landowners were forced to rent their estates to the surviving farmers, whose labour was now in high demand against crippling inflation and who became independent for the first time. This freed up capital and made society more economically mobile, possibly leading to the birth of a kind of proto-capitalism, but it also led to the 'lost villages'.

As well as being depopulated through disease, the estates of the rich also succumbed to the fat dowers of widows who were entitled, for life, to a third of their dead spouse's income. With the death rate increasing and ageing spinsters gobbling up inheritances, young lords were as out of pocket as the poor and stood no better chance against Pestilence. While the chronic overpopulation in England before the Black Death meant that there was no initial effect on the labour market, by the next generation – the 1370s – there was a critical shortage. This led to the British government passing increasingly stringent regulations aimed at holding down rising wages, and ultimately to the Peasants' Revolt of 1381. The same was true elsewhere in Europe, with the effects of the Black Death also leading to the Jacquerie in France (1358) and the Revolt of the Ciompi in Italy (1378).

Despite the reassurance that the clergy provided, religion was powerless against the Black Death. Churchmen, who were often the closest thing to a doctor, were forbidden to dissect the bodies of God and so could not perform autopsies to learn the exact causes of death. Priests afraid of the plague refused to administer last rites, and urged people to confess to each other. Funeral rites were similarly abandoned, with corpses stacked several layers deep with a smattering of earth between each row, and entrepreneurial peasants began to gather and bury the dead for a fee.

Eventually, the clergy refused bodies entry into cities and, since death had become such a constant companion, ordained that no funeral bells were to ring. In 1348, however, a much greater religious threat abounded. The Brotherhood of Flagellants rose up in Germany and led 1,000-strong marches through the country for 33 and a half days at a time (to mark the Saviour's years on Earth), brutally whipping themselves with iron-studded belts of leather to display their penance to God and earn protection from his wrath. They had something of a rockstar status and many people reached out to catch the sacred drops of blood that spattered from their holy wounds.

By 1349 the movement had petered out – falling prey to a bandwagon effect that led to too many misfits and vagabonds exploiting the Flagellants' notoriety – but the effect it had on public sentiment was grave. The reinforcement of extreme Christian ideology in the face of the apocalypse inflamed anti-Semitism across Europe and the Jews were persecuted like never before.

Associated as they were with the mystical Kabbalah (and black magic), the 2.5 million Jews living in Europe at the time were prime suspects for witchcraft and nefarious deeds. Having been strong international merchants in 1000, they were in a period of decline that would ultimately lead to their replacement in economic terms by Italian merchants by 1500. Divided and wandering across Europe, they were accused of brewing poisons and then infecting wells with disease.

False confessions under torture, such as that of Agimet the Jew during the plague's peak in 1348, didn't help matters, and on Valentine's Day of 1349 in Strasbourg 2,000 Jews were burned in a cemetery. The crime was repeated in other cities across Germany and Switzerland, prompting a mass Jewish migration across Europe.

It was to Poland that they fled, as King Casimir was in love with a Jewish woman and so opened the borders of his country to his lover's kinsmen, where they would remain until the devastation of the Holocaust. Yet while the Jews were fleeing death and destruction at the hands of humans,

"The plague had claimed an estimated 40-50 per cent of the European population – that's around 20 million people"

the monster itself was winding down. Pestilence reached Sweden in 1350 and, by the time it got to Russia, the plague had all but passed in France and England.

Historians have never reached complete agreement on what exactly stopped the disease from continuing to burn through the population, though quarantines, slightly better hygiene and the reduced number of people travelling back and forth through Europe – as a result of mass depopulation and a growing fear of infective trade routes – are all thought to have played a role. The plague had claimed an estimated 40-50 per cent of the European population – that's around 20 million people. By way of comparison, the Spanish flu that followed the end of WWI in 1918 claimed 50 million lives. Never before or since has such a potent infection wracked the continent.

Unaware of the true nature of the monster, many believed the Black Death was a miasmatic illness, caused by noxious, pestilential fumes in the air. As such, posies were carried and incense burned in homes, people forwent bathing (as it opened the pores) and even splashed themselves in urine to bolster their natural protection against external fumes and vapours.

Some historians believe that the Great Fire of London (1666) – which wiped out the black rats – was the only thing that saved England from succumbing to the plague entirely. It took Europe centuries to fully recover, and those who survived believed they had witnessed the apocalypse.

Funerals for plague victims would often be performed at night to limit contact with other people

TENERIFE AIRPORT DISASTER

Two fully-fuelled Boeing 747 aircraft collide on a runway. It remains the deadliest incident in aviation history

From out of a rolling bank of fog cloaking the runaway at Tenerife's Los Rodeos Airport, they saw two pale beams. At first glance, the hazy lights looked stationary. Only the growing intensity said otherwise. Then, the behemoth Boeing 747 emerged from the gloom. Pan Am Flight 1736's captain, Victor Grubbs, first officer, Bob Bragg, and flight engineer, George Warns, could not quite believe it.

In all their years and experience as commercial airline pilots, what was moving toward them was an inconceivable image; something from a nightmare, not reality. At a distance of 700 metres and closing in at 258 kilometres per hour, was KLM Flight 4805. Nine seconds later, at 5.06pm, on 27th March 1977, two Boeing 747 jumbo jets collided.

"Goddamn, that son-of-a-bitch is coming!" Grubbs had made a valiant attempt to get his plane further off the runaway, pushing on all four throttles. Thanks to his actions, there would be a handful of survivors. Not many walked away from the crash, and those that did were immensely lucky. If the Pan Am jumbo jet had not been turned on its side, the KLM 747 would have hit it head on and the loss of life would have been complete. No survivors.

Today's aviation technology is so advanced that crashes should be even more of a rarity than they already are. It is one of the safest modes of travel. Car crashes happen every single day, plane crashes don't. Yet for all the latest technological innovations, ingenuity and engineering feats, one statistic has caused a worrying increase: pilot errors now account for 50 per cent of all aviation incidents.

That the number has risen in recent years and surpasses what industry experts refer to as 'catastrophic' mechanical failures (accounting for 20 per cent of incidents) is worrying. But the Tenerife Airport disaster was a different kind of pilot error. As well as an aviation disaster, it reads like a cruel tale of hubris; what happens when a star employee does something so wrong, it beggars belief.

Jacob van Zanten was KLM's poster boy – literally. He fronted their ad campaigns and was considered to be the best of the best. The 50-year-old mostly spent his working life training others in simulators. When KLM bosses first got wind the incident, they wanted van Zanten to lead the investigation. Told he was involved in the calamity on Tenerife, they were gobsmacked. Dutch authorities and KLM were reluctant, initially, to blame hot-shot Captain Jacob van Zanten. But it was their man's decision-making which caused the deaths of 583 people.

KLM Flight 1736 had been pushed for time. Airline pilots must take enforced breaks, if they go over an allotted flight time limit. Van Zanten's professionalism and dedication to KLM meant the rules were already being pushed. His impatience, at first, was understandable enough. Terrorists were inconveniencing the flight and all its passengers. Then, the weather changed for the worst, just as Las Palmas radioed in to Tenerife informing them the

"Jacob van Zanten was KLM's poster boy. He fronted their ad campaigns and was considered to be the best of the best"

IN BRIEF

- **Death toll: 583**
- **Los Rodeos Airport, Tenerife**
- **27th March 1977**

A deadly collision between two 747 jumbo jets occurred on the runway at an airport on the island of Tenerife. A catalogue of factors led to a tragedy with a staggering body count.

airport had reopened for business. But here they were in a traffic jam on an island they weren't even supposed to be on, the weather turning for the worst, faced with the very real prospect of forcing a stopover for the night, which would cost the company thousands of dollars it shouldn't have to be spending.

Weather factors were involved in what happened. Political unrest on the Canary Islands played a vital role. Control tower failures and language-based communications issues also contributed. Yet the decision to push forward on the thrusters was down to one individual's arrogance, impatience, fixation with time-saving and a cockpit culture where the captain's word was the law and a stringent hierarchal structure forbade first officers or others from questioning their leader.

The size and location of Tenerife's Los Rodeos Airport was another important factor. It certainly wasn't built to deal with giant aeroplanes congregating all at once. The real kicker, however, was neither 747 was supposed to be on Tenerife. A terrorist incident at their original destination – Las Palmas on Gran Canaria – had diverted all air traffic until further notice. When Las Palmas reopened, the control tower operators decided planes should follow the runway down to the end, make an about turn and take off. As an idea, it was fairly routine and straightforward. In the industry, it's known as a 'back track'.

"Now on fire, Flight 4805 rolled. Engulfed by a series of explosions, every man, woman and child was incinerated by the flames"

The control tower operators – who would be accused of paying attention more to a football game on the radio than the intricacies of navigating planes to safe take-offs – had lost sight of the 747s in a sudden enveloping sea of fog. Due to the elevation of Los Rodeos, it was prone to fog banks coming in off the mountains. Weather conditions were in danger of causing further disruptions and the control tower was increasingly jittery. If it got any worse, and with a light rain falling, there was a very real prospect of flight cancellations. Holidaymakers would be stuck on an island they hadn't planned on visiting.

The Pan Am 747 had been crawling at five kilometres per hour searching for a taxiing exit. The flight crew were already feeling nervous, due to the poor weather conditions and they'd experienced several communications mix-ups. The crew were unsure of which exit to take and the one they'd been directed toward made no sense, as it was on a hairpin, 45-degree angle. They double-checked the information but it made not one lick of sense. So, they proceeded to another. After all, it would have been very difficult to pull off such a manoeuvre in a 747, where the cockpit is ten metres above ground. It was more logical to take the fourth exit, known as C4.

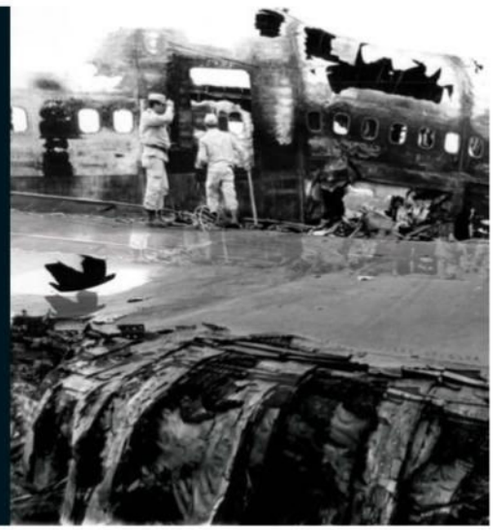
As KLM Flight 4805 emerged from the fog and spotted the Pan Am craft in its path, Captain Jacob van Zanten attempted a desperate lift-off. This dramatic action caused a tail strike, dragging the back end of the plane along the ground. There was just about enough power to get the KLM's nose off the ground, but its fuselage, engines and wings careened into Flight 1736. For some, death was instantaneous. Now on fire, Flight 4805 rolled slightly, smashed into the runaway and skidded for 200 metres before stopping. Engulfed by a series of explosions, every man, woman and child was incinerated by the flames. Aircraft circling above

MAJOR INDUSTRY CHANGES

Lessons are learned from all aviation disasters, but the incident at Los Rodeos Airport was an industry-changer. This occurred in two ways. Firstly, the need was obvious for standardised phraseology between control towers and pilots. Secondly, the culture in which the captain was king needed tackling. It was encouraged that, if a first officer or other member of the crew had an issue with their captain's decision-making, they were to speak up.

Experts from Holland, Spain and the USA conducted investigations and all were critical of the manner in which the control tower communicated with pilots. It wasn't that they spoke English with Spanish accents and the KLM flight crew spoke English with Dutch accents, it's more what was and wasn't being stated clearly. Radio communication failings also added to the unfolding drama.

The transcript from the flight data recorder told investigators that control tower operators used words and phrases which could lead easily to misinterpretation. Not only that, they sometimes got the flight numbers wrong and seemed hesitant. It was claimed, too, and backed up by noises heard on the Flight Data Recorder, that the control tower operators were listening to a football game on a radio. For example, the word 'okay' is not standard phraseology in aviation. Its ambiguities are apparent as much as its potentially disastrous nuance. It can be a form of agreement and acceptance. Both sets of pilots and the control tower were using it. When Klaas Meurs radioed in to say they were at 'take-off' the control tower interpreted it as 'in take-off position awaiting clearance'. They responded with 'okay'. 13 seconds later, almost 600 people were dead.



A survivor is rushed to hospital by emergency workers

Los Rodeos radioed into the control tower to tell them they'd seen a gigantic fireball roar into the sky. Black smoke billowed up and up.

First Officer Bob Bragg described the moment of impact as somewhat deceiving. He heard little more than a shudder and a popping noise. Had the KLM Boeing 747 merely scrapped the top of the fuselage? Only when he turned around did his brain registered the full extent of the horror. The jumbo jet's entire roof had been sheared off. He could see all the way to the tail. Those in the back section and the middle and most of the front were killed instantly. If not, they would suffocate from lack of oxygen, as the flames consumed the interior of the craft and it collapsed in on itself.

61 Pan Am passengers, though dazed and confronted with a profound change in their lives - which seconds ago had been equally profoundly normal - walked away from the wreckage. Survival mode kicked in for some and they took advantage of a collapsed door, which led out to the right wing. They had to act fast because the fuselage and the wing was ready to fold in and collapse. Many broke bones jumping onto the grass below.

Captain Victor Grubbs dropped from the cockpit through the floor to first class. The floor gave way and he continued downwards into the cargo area. He suffered horrifying burns to his arms and legs. But he lived. Survivors congregated on the grass away from the Pan Am jumbo jet, some in absolute agony due to their wounds, others left unscathed but struggling to comprehend what had happened minutes earlier.

The first of van Zanten's life-changing errors was refuelling the aircraft on Tenerife. His co-pilots questioned him about this. The flight to Las Palmas was 25 minutes. But they were overruled. This further heightened van Zanten's irritability. He saw it as another time-saving exercise because he believed traffic at Las Palmas would be hectic and they'd only be waiting around. KLM Flight 4805 was carrying 55,500 litres of fuel - more enough to see the jumbo jet all the way back to Amsterdam. The decision to refuel would be the point of no return. 55,500 litres of jet fuel igniting on impact exacerbated things dramatically.

As the KLM crew backtracked their 747 down the runway, the atmosphere changed. Clear visibility was reduced to almost zero. KLM Flight 4805 turned around and prepared not to wait but to take-off. Quite incredibly, van Zanten began to push forward on the thruster. Castigated by his co-pilot, which took some guts, van Zanten tersely ordered First Officer Klaas Meurs to radio the tower and seek clearance. What they did receive from control tower operators was their flight path instructions once they were in the air.

Under no authority but his own, van Zanten pushed forward on the throttles once again. Take-off was initiated. There was no going back. Van Zanten is heard on black box flight recorder announcing 'Oh, yes' to a crew's question, as to whether the Pan Am was actually clear from the runaway. He did not know and he could not know.

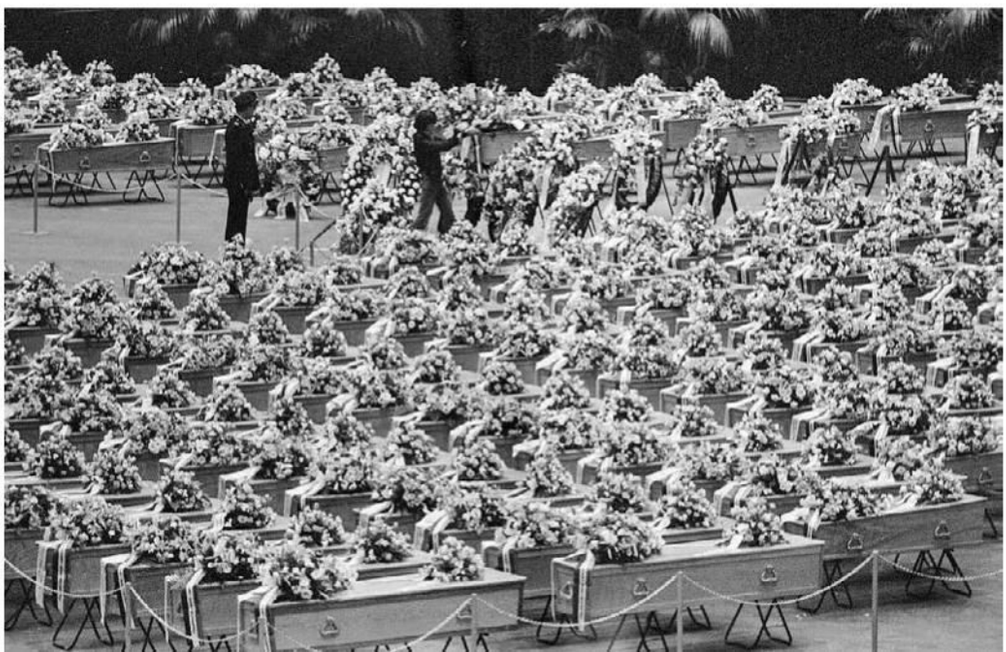
The final sounds picked up by the flight data recorder were screams...

THE FIRST AGE OF GLOBAL TERROR

The 1960s and 1970s was the first age of global terrorist organisations. Marxist groups outraged by capitalist western society and governments, hijacked planes, assassinated politicians and commenced bombing campaigns at specified targets. In Spanish territories, such as the Basque region and the Canary Islands, nationalist-separatist groups rallied against what they believed to be their colonialist overlords.

Terrorism played its role in events on 27th March. While not the direct cause of the crash, it was very much a key component in the tragedy. Terrorist leader of the Canary Islands Independence Movement, Antonio Cubillo, stated to the world in a television interview: 'What everybody has to understand is the Canary Islands are at war. As long as the islands are a colony, they will be at war with Spain. If the Spanish government doesn't agree to our three conditions, we launch full armed combat and fight to the very end.'

The Fuerzas Armadas Guanches (Guanche Armed Forces) operated from 1976 to 1978. Planting an explosive device in a flower shop at Gran Canaria airport caused the diversions to Tenerife's commercial but much smaller regional airports. Not even the Guanche Armed Forces would have predicted the strange outcome of their actions.



IN BRIEF

- **Death toll: 57**
- **Washington, USA**
- **18th May 1980**

Mount St Helens was one of the first volcano eruptions to be widely photographed, and it was accompanied by the largest landslide the world has ever recorded

MOUNT ST HELENS ERUPTS

When Catherine Hickson witnessed the 1980 eruption of Mount St Helens, she learned to expect the unexpected. It changed her life forever

It was eerily quiet. In the distance, some 14 kilometres west, Mount St Helens – which had so often been seen as the most perfectly symmetrical of mountains – was steaming heavily from its fluted snow-covered top. The 2,950-metre-high volcano in south-western Washington state had been awoken by a series of earthquakes since the beginning of March 1980 – one of which had a magnitude of 4.2. But while that rocked the tranquil surroundings of the USA's fire mountain and opened twin fissures on its north face, there was still a sense of silent peace, at least from where Catherine Hickson was standing.

On the inside, the third-year geology student was bursting with excitement, and she wasn't the only one. Tourists, reporters and scientists – both professional and amateur – had flocked to the area in the hope of catching the full view of Mount St Helens' anticipated eruption. Yet while they jostled for the best positions and there was some arguing as a number of residents refused to leave their homes, Hickson had taken up position on a remote rock quarry directly facing the volcano. She had decided to camp out for the weekend with only her husband, Paul, for company, having driven for seven hours down from their home in Vancouver.

For her, it was a no-brainer. "Everyone in the geology departments had been talking about it and I was interested in volcanoes and volcanology," she said. "It was the first time that there had been active volcanism in the Lower 48 and because it was so close by, we just had to go." The couple left their home on Friday 16th May and, as they got near to their destination, they spotted a forest road – a non-public track that had been created by a logging company that was operating in the area. "We followed it along the east side of the volcano and found a place where they had been taking gravel, a kind of flat spot. It was the Victoria Day long weekend in Canada so we were able to stay until the Monday." As it turned out, they didn't need that long.

The following day, Hickson was starting to become restless. "We could clearly see Mount St Helens and it was lovely weather, very hot. We could see steam from the summit but it was so quiet that on the Saturday afternoon, I suggested that we should go somewhere else, but we didn't." The following day, they woke early and had a breakfast of eggs and bacon. Then, at 8.32am, as they sat together in their campervan looking close up at the volcano through a shared pair of binoculars. It was then that they felt an earthquake of magnitude 5.1.

Slightly closer to the volcano was David A Johnston, a principal scientist on the monitoring team, whose observation post was ten kilometres away from the action. He had been confident that the seismic activity being recorded by the United States Geological Survey stations was pointing towards an imminent major eruption, and during his time on the ridge, he'd noted the changes to Mount St Helens. The alterations to the mountain's structure had mainly occurred after the phreatic eruption of 27th March sent a plume of ash 2,134 metres skywards. In the aftermath, the crater had been excavated and a second caldera created. But a number of relatively small eruptions continued to take place, and a bulge – known as a cryptodome – on the north flank had appeared within a couple of weeks, growing two metres each day. "Vancouver! Vancouver!," Johnston shouted into his radio as the clock struck 8.32am and he too felt the tremendous rumble. "This is it!"

Hickson and her husband couldn't take their eyes off the volcano, and within seconds, the drama they had been waiting for from the advantage of their elevated front row began to unfold. "The whole mass of the north-eastern side of the volcano had been pushed out, steepened and broken up," Hickson said.

"Magma had risen inside, found the volcano's weak spots and exerted outward pressure but now gravity had taken over. The side failed because it had been pushed up too far."

The couple were mesmerised. "We saw the beginning of this failure. We saw the landslide," she said. "And as it progressed down the side of the volcano, it was releasing its pressure." The north face was sliding down in an avalanche of

debris at up to 250 kilometres per hour. More than 2.5 cubic kilometres worth of deposits cascaded towards northern ridges and the westward valley. "It was the largest landslide ever witnessed," said Hickson. "A few kilometres of material slid off the mountain - something that was unrecognised in its association with volcanic eruptions."

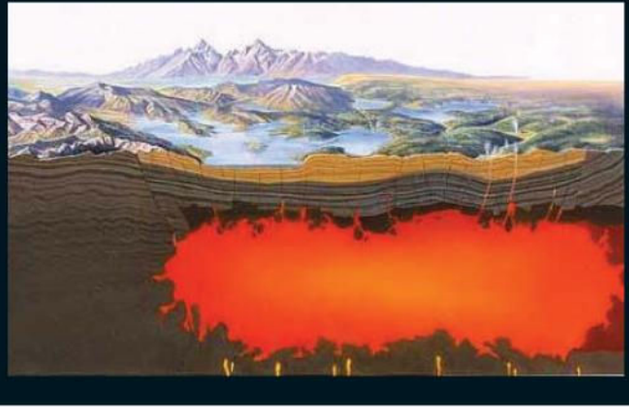
With the northern flank exposed and the cryptodome removed, the stratovolcano's magmatic system was suddenly depressurised. The volcano erupted at its summit and, as the landslide progressed, there was a secondary explosion. "It decapitated the conduit," Hickson said. After 100 years of stillness, Mount St Helens was brought to life in the most dramatic of fashions. Instead of erupting upwards, it erupted sideways, surprising everybody who was watching. The lateral blast travelled at 482 kilometres per hour and ash was sent some 25,000 metres into the air.

The pyroclastic flow surged; the hot gas, ash and rock reaching temperatures of 350 degrees Celsius. Within minutes, an area of 370 square kilometres was levelled, destroying hundreds of homes, smashing bridges and sending ash across 11 states. Trees were felled as much as 25 kilometres away and the area was plunged into darkness as the black, billowing clouds filled the sky. The noise was a tremendous blend of roars and rumbles. "Initially it was incredibly exciting," said Hickson. "It was an amazing thing to witness. Essentially a huge chunk of the volcano slid away and this incredible explosion was occurring."

But there was a terrible human cost. Following the blast, 57 people were instantly killed as the area around them was destroyed. Johnston was among them, his positioning within the direct blast zone that radiated 13 kilometres proving fatal. It has been said that the blast was equal to 24 megatons of TNT, yet even those further away were not safe. "We had to flee," said Hickson. "When the landslide occurred, it exposed the north flank and it had this big buttress that was left behind. It directed the blast 32 kilometres to the north and it tumbled down the slope in front of us, progressing towards

"The area was plunged into darkness as the black, billowing clouds filled the sky"

USING CRYSTAL-CLEAR THINKING



Scientists have continued to monitor Mount St Helens in the hope of understanding the cause of the eruption. In June 2016, Professor Jon Blundy, the lead researcher from the School of Earth Sciences at the University of Bristol, said he believed the rise of dateable crystals within the magma could point to destabilisation and a possible eruption.

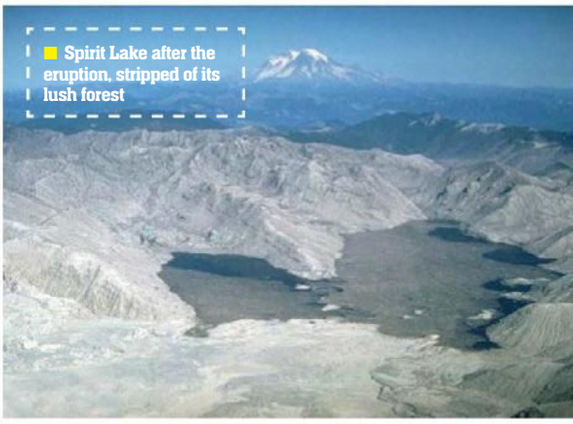
"These crystals are zoned and they grow a bit like tree rings – you can use the zoning patterns to discover where in pressure, temperature and time-space the crystals were in the lead up to an eruption," he told us. "The data from Mount St Helens shows that the crystals spent the early part of their lives at depths of 12 or 14 kilometres in what you may describe as a long-lived magmatic mush. These reservoirs could have been there for tens, hundreds or thousands of years."

Using the crystals, scientists should be able to work out where and when the magma moved. "We have noticed that magma is moved up to four or five kilometres in a timescale of a few years and then there is an eruption pending. From that, we can see that a quick upward movement of magma indicates a lead up to eruption over the next few years."

Such thinking is vital in coming up with ways to predict when a volcano will blow well before it does, allowing for ample warning and evacuation plans to be drawn up. "There are various aspects of Mount St Helens that make it amenable to studies," he said.

"I've been lucky with Mount St Helens because it's a simple volcano. It erupted a few months before I started studying geology at university so it was significant for me too," Blundy added.

The Washington National Guard were instrumental to rescue efforts



Spirit Lake after the eruption, stripped of its lush forest

the east. That's when we realised we were in grave danger." As they drove south at speed, Hickson could see the cloud behind their vehicle. Her husband's camera had been used to snap away at the volcano's progress but he was trying his hardest to avoid the results of the earthquake; the rocks that were blocking paths.

Muddy rain fell but they continued on their two-hour journey. When they later returned to their makeshift campsite, the danger they had been in hit home. "It was covered in a small hail and several centimetres of ash," she said. "I'm glad we didn't try to stay." Yet that day remained with her forever. She pursued a career in volcanology and, today, the student who was studying sedimentology at the time is now Canada's most celebrated volcanologist.

Following the eruption, the mountain was not as majestic as it once was although both it and the adjacent forests and streams became classed as a National Monument. The mountain had fallen from being Washington state's fifth-highest peak at 2,950 metres to 2,550 metres - which now puts it in 52nd place. The eruption had changed the landscape forever too, killing animals, stripping soil and dirtying clear lakes. Cars were left stranded, almost melted into the earth.

President Jimmy Carter visited the area following the eruption, and in a conference with journalists, he told reporters: "I don't know how long it'll take for that region to be open even for normal movement of traffic. Enormous blocks of ice apparently are still covered by literally hundreds of feet of fluffy, face-powder-type ash, and as that ice is melted under the hot conditions that exist, enormous cave-ins are taking place. Steam is bubbling up. There are a few fires about. Someone said it was like a Moonscape but it's much worse than anything I've ever seen in pictures of the Moon's surface."

But despite the $1.1 billion of damage caused to local industry, the area has become crucial for volcanologists, especially since Mount St Helens remains active and has erupted on a smaller scale on numerous occasions since. The lives lost have not been forgotten, though: the US Geological Survey office in Vancouver was renamed the David A Johnston Cascades Volcano Observatory and the Johnston Ridge Observatory, which was built in 1997, sits roughly nine kilometres from the crater. Its visitor centre affords great views.

"Mount St Helens was an important eruption from a scientific viewpoint," Hickson said. "That is partly due to the sector collapse, the huge landslide that decapitated the upper part of the magma chamber and the sideways blast as opposed to a vertical eruption." Hickson ended up completing an undergraduate thesis on pyroclastic surge deposits, detailing the fluidised mass of ejected volcanic rock fragments and turbulent gas that result from such eruptions.

"The volcano contributed significantly to our understanding of how these kinds of stratovolcanos erupt," she said of the volcanos that are built up of alternate layers of lava and ash. "When scientists looked back over the seismic records of Mount St Helens, they saw that seismicity had started a couple of years prior to the eruption. They also learned about the interaction with snow and glaciers that were on top of the mountain. The magma had descended into the volcano and melted the ice and snow, creating a very saturated mass around the cryptodome. That had never been witnessed before."

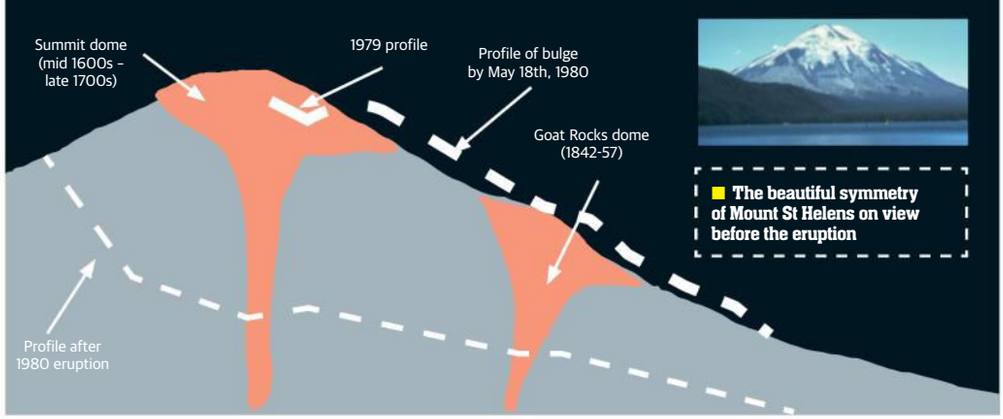
Mount St Helens remains active, with significant activity between 2004 and 2008 creating plumes of steam and ash visible as far away as Seattle. Its rugged terrain and challenging slopes are also popular with mountaineers. But Hickson will never forget that day in 1980 when the mountain roared. "I always say if something almost kills you, then it's nice to learn something about it."

UPS & DOWNS

The eruption of Mount St Helens devastated the mountain and changed its appearance for ever. The first noticeable feature was the emergence of the cryptodome, the side bulge that was caused by viscous magma pushing out from the surface. This altered the shape of the mountain on its north flank and it led to destabilisation.

When the cryptodome collapsed and created a landslide, the northern flank was removed and the powerful eruptions were triggered. As they blasted out twice from the side of the volcano, emitting a lateral blast of hot material across more than 30 kilometres, magma expanded upwards towards the opening of the vent and there was a Vesuvian eruption that sent plumes of ash about 25 kilometres directly upwards. An ash cloud spread across North America over three days.

When the volcano had settled down, its height had dropped significantly and it took on an entirely different profile. Life is slowly returning to the mountain after the devastation. Trees were the first to revegetate thanks to their seeds being protected by snow and vegetative cover. Elk and deer began to make a comeback too. But it's not the end: between 2004 and 2008, there was a gradual extrusion of magma and a new lava dome has been created.



The beautiful symmetry of Mount St Helens on view before the eruption

IN BRIEF

- **Death toll: 300-400**
- **The Solent strait, England**
- **19th July 1545**

The scale of the disaster, the mysteries behind its cause and the clues it has left behind made the sinking of the Mary Rose one of the key historical moments of the Tudor period.

THE SINKING OF THE MARY ROSE

This famed Tudor ship was Henry VIII's pet project, but why did his fleet's flagship sink suddenly in the Solent?

As the last vestiges of the *Mary Rose* were consumed by the very sea it had sought to conquer, the men who had not yet perished aboard the ship could not have known that they were to become part one of the greatest archaeological sites of the Tudor period, preserved like no other for the keen historians of the 20th century to marvel at and analyse for decades. This particular disaster, unexpected and perhaps entirely unnecessary, was rare – the loss of life may have seemed futile, but without it, we might have a very different understanding of the Tudor period. But it is not only for its immense bounty of historical artefacts that the *Mary Rose* has endured as one of England's (and, perhaps, the world's) most notable shipwrecks. It is also, as ever, the mysteries surrounding its story that it endures as a point of fascination for history enthusiasts and experts alike. There is plenty we can't be sure of when we ask that simple-sounding question, 'what sank the *Mary Rose*?'

What we do know is that the *Mary Rose* was commissioned by Henry VIII, as part of a new sea army. He had inherited a rather measly fleet and set about improving it for the many battles that lay ahead, with sea ships known as carracks – the *Mary Rose* and another commission, named the Peter Pomegranate. Historians still debate exactly who the boat was named after (if indeed, she was named after a particular person at all, as this was not the trend at the time) – popular belief often sides with Henry's sister, Mary Tudor, while it is generally considered more likely that the name was a tribute to the Virgin Mary, known at the time as the 'Mystic Rose'. This also chimes well with the naming of the *Peter Pomegranate*, as the pomegranate is a symbol of resurrection and eternal life – often associated with Jesus Christ. The fruit is even shown in the hand of the infant Jesus in some depictions of the Madonna and Child. The pomegranate was also a symbol of the house

of Aragon, which was certainly a consideration when Henry chose the name for the boat, having married Catherine of Aragon to strengthen political alliances – when they were divorced, Henry renamed the *Peter Pomegranate* as the *Peter*.

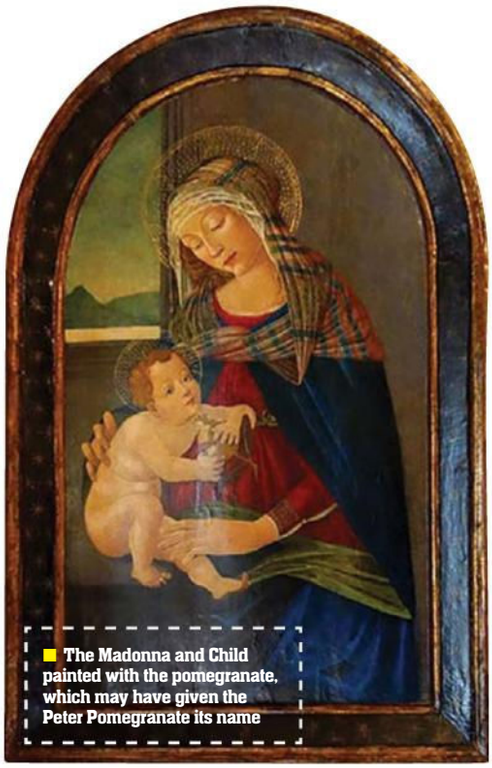
But the mysteries certainly don't end with the boat's name. The end of the *Mary Rose* came suddenly, on 19th July 1545. Having survived a glittering career of three French wars, from 1512 to 1545 (with rest and restoration in between), the *Mary Rose* was sunk dramatically in the Battle of the Solent, much to the surprise and delight of the French. It was a stacked battle – the French fleet numbering 128 ships, while Henry's was just 80. But it was soon to be down one notable ship.

The French account of the battle tells the story thus: that on the morning of the fateful 19th July, after two days of battle with no real loss to either side, French ships made an attempt to lure the English out of their relative safety in the Solent to come within easier range of the French galleys. The weather had been calm all day – and yet suddenly, the *Mary Rose* began to sink.

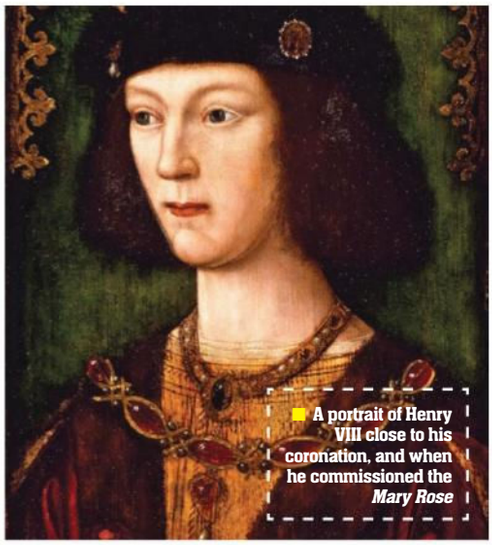
If we look to the English records, the events played out slightly differently. Henry VIII had been dining with Admiral Viscount Lisle on the fleet's pride and joy, the *Henry Grace a Dieu* the night before the sinking. At dinner, Henry bestowed the *Mary Rose* upon George Carew, which, with the *Mary Rose* being the fleet's second largest vessel after the *Henry Grace a Dieu*, promoted him to the heady heights of vice admiral of the fleet. Little could he know, he would soon be in charge of a ship that was doomed for failure. Some accounts claim that Henry VIII looked on from Southsea Castle as the *Mary Rose* sank – we can only imagine today how it would feel to see the flagship of your fleet sink, without discernible reason.

Whichever order of events is correct, whether French or English, the question remains: what was the cause of this sudden trajectory toward the abyss? There are four main theories for the ship and crew's shocking demise. The first of these stems from the same French accounts referenced previously, in which one lone French cavalry officer claimed that the ship had been sunk by the onslaught from French guns, which had been in the process of trying to goad the English into coming further away from the shallow water at Spitbank. The likelihood of this would depend upon the position of the hit; if it was a cannonball low in the ship's hull, water would inevitably leak into the vessel causing an upset to the balance, resulting in the ship's toppling over.

Another theory is that the ship had been overloaded, either with guns, with men or both. The ship had, during improvement works while it was kept in reserve between 1522 and 1535, gained an extra capacity of some 100 tonnes. The ship was caulked and made as new, and was fitted with extra bracing, indicating that the *Mary Rose* was



■ The Madonna and Child painted with the pomegranate, which may have given the Peter Pomegranate its name



■ A portrait of Henry VIII close to his coronation, and when he commissioned the *Mary Rose*

THREE FRENCH WARS

The reason for the *Mary Rose*'s outing on the Solent, was a strategic battle, its last in a series of three, against the French. The first had begun in 1512, led by Sir Edward Howard, Lord High Admiral of Henry's fleet, with the Mary Rose as his flagship. The ship had raided Brittany, with 12 Breton ships captured. Upon returning to Southampton following this success, Henry VIII graced the ship with his presence, visiting briefly before it sailed out again to Brest, to the Battle of St Mathieu. It was by all accounts another success. The *Mary Rose*, it seems clear, was a formidable ship at the start of its career.

Following this, the ship was involved in skirmishes and played its part in the Battle of Flodden Field, carrying troops to Newcastle. In the autumn of 1513, Henry's sister Mary was married to the King of France, Louis XII, which ended the wars – for now, at least.

By 1522, the calm relations between the English and French were already over. The *Mary Rose* set off again ready to capture the port of Morlaix, Brittany, on 1 July. It went off without a hitch, and the ship returned to Dartmouth triumphant. The Scots joining forces with the English in 1525 brought about success once again in this war, and the Battle of Pavia brought an end to the war.

The third in this series of wars was in 1545, as a result of Henry's vulnerability following the break with Rome, and a promise made to Charles V, Holy Roman Emperor, in 1544, intended to make political alliances. But Charles made his own pact with the French, leaving Henry to fight his own battle – the battle that ended the *Mary Rose*.

expected to carry heavier loads in the future. We can't know for sure exactly what changes were made, but it has been suggested that extra gun ports were also cut to allow greater fire power. However, it's generally considered unlikely that overloading with guns could be the reason for the topple, as the ship had successfully made the journey from London.

Overloading of soldiers is a much more likely contributing factor in the disaster. The ship was built to hold 400 men, but reports state that 700 were aboard. Imagining the scene of panic among the crew and soldiers as the boat began to sink suddenly, packed like sardines with no escape route, is truly sobering. For the underwater archaeologists who uncovered the bodies of many of those men on board four centuries later (the wreck was rediscovered in 1836 by a local fisherman, and in 1965 a local diving group, led by a diver called Alexander McKee, identified the first part of the ship's wreck), it must have been a truly shocking, while certainly exciting, sight to behold.

A catastrophic case of human error is cited as another possible explanation for the ship's end – with a crew of 700 men, it is not beyond the realms of possibility that in the heat of the battle, a crew member could make a fatal mistake, perhaps leaving open a spot that should have been defended, or failing to close a gunport.

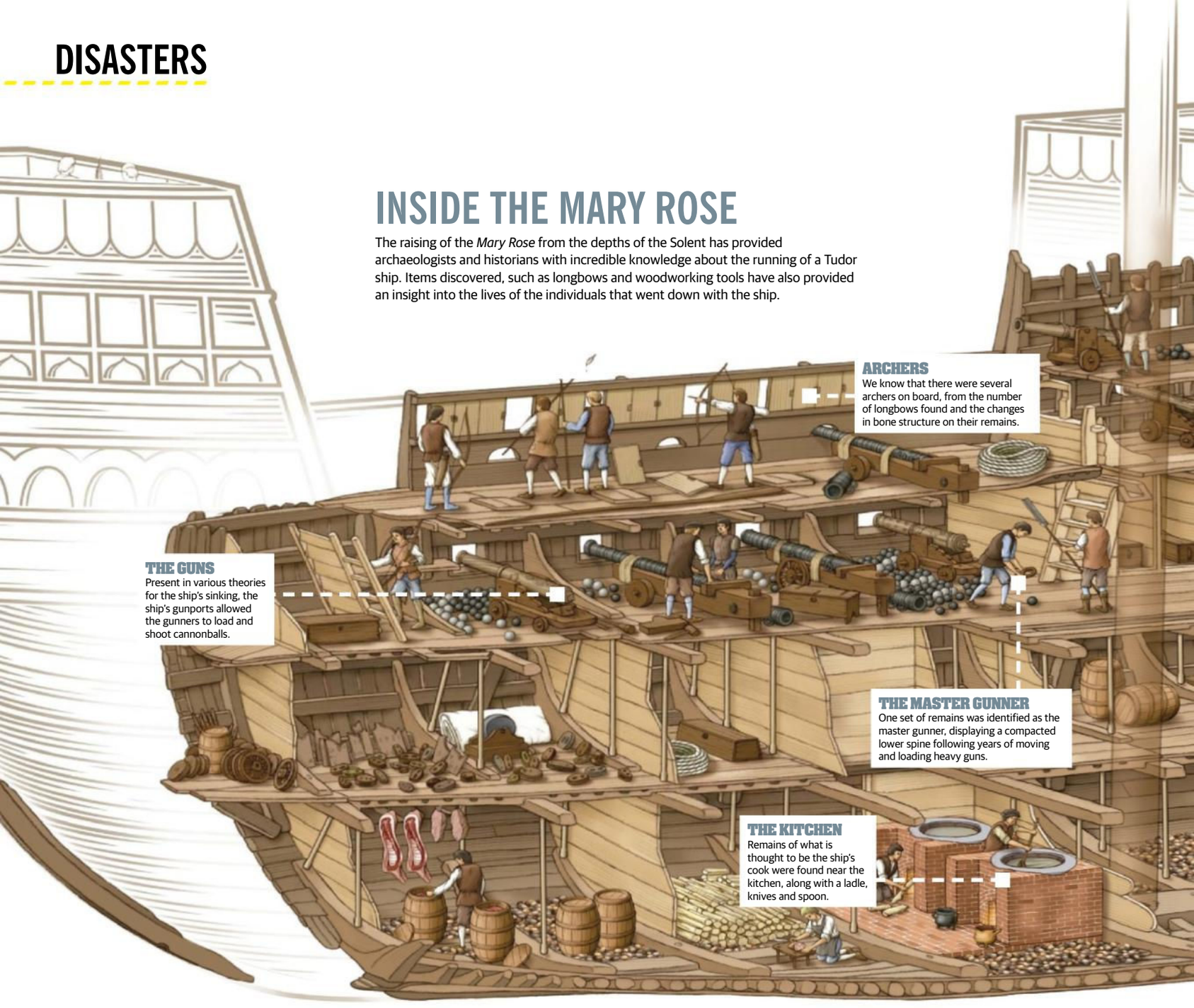
A final theory which seems almost too simple to have claimed the lives of so many men is that a rogue gust of wind caught the ship while it was in a vulnerable position, turning to make use of the guns on its other side. Whichever of these theories tells of the deciding factor, we do know that after the initial tipping of the ship, seawater gushed in through the gunports, sealing the fate of the ship and its men once and for all.

"For the underwater archaeologists who uncovered the bodies of many of those men on board it must have been a sight to behold"

Dr Peter Marsden, a historian and archaeologist specialising in Tudor ships, and editor of the book *Mary Rose: Your Noblest Shippe* – which examines what we know about the ship and her structure – considers that the most likely theory is also the most tantalisingly simple. He told us: "It seems that the reason given for the sinking in 1545 applies. It was simply that on a day of a quiet breeze, the ship had her gunport lids open having just fired at a French warship, when an unexpected gust of wind heeled her over and she flooded." This is in line with a rare eyewitness account of the tragedy, which reported that the ship had fired all of her guns and was turning in order to use the guns on the opposing side, when she was ambushed by an unexpected gust.

INSIDE THE MARY ROSE

The raising of the *Mary Rose* from the depths of the Solent has provided archaeologists and historians with incredible knowledge about the running of a Tudor ship. Items discovered, such as longbows and woodworking tools have also provided an insight into the lives of the individuals that went down with the ship.



However, Dr Marsden is also keen to consider the impact of communication and possible human error in the events leading to the tragedy: "It could also be that having many foreign nationals who could not speak English on board, added to the problem in that they did not understand orders in English," Marsden told us, bringing to light another factor that likely contributed to the disaster.

Analysis on the skeletons of the bodies found with the *Mary Rose* revealed that some of the men aboard were not British, but of Mediterranean or continental European extraction. This could have caused a fatal language barrier that made orders much more difficult to follow for the seamen. However, analysis also suggested that the majority of the men hailed from England's west country. It is claimed that the admiral, Sir George Carew, of the *Mary Rose* cried out during the chaos that he was in charge of the "sort of knaves I cannot rule", hinting at disobedience and perhaps incompetence on board the ship.

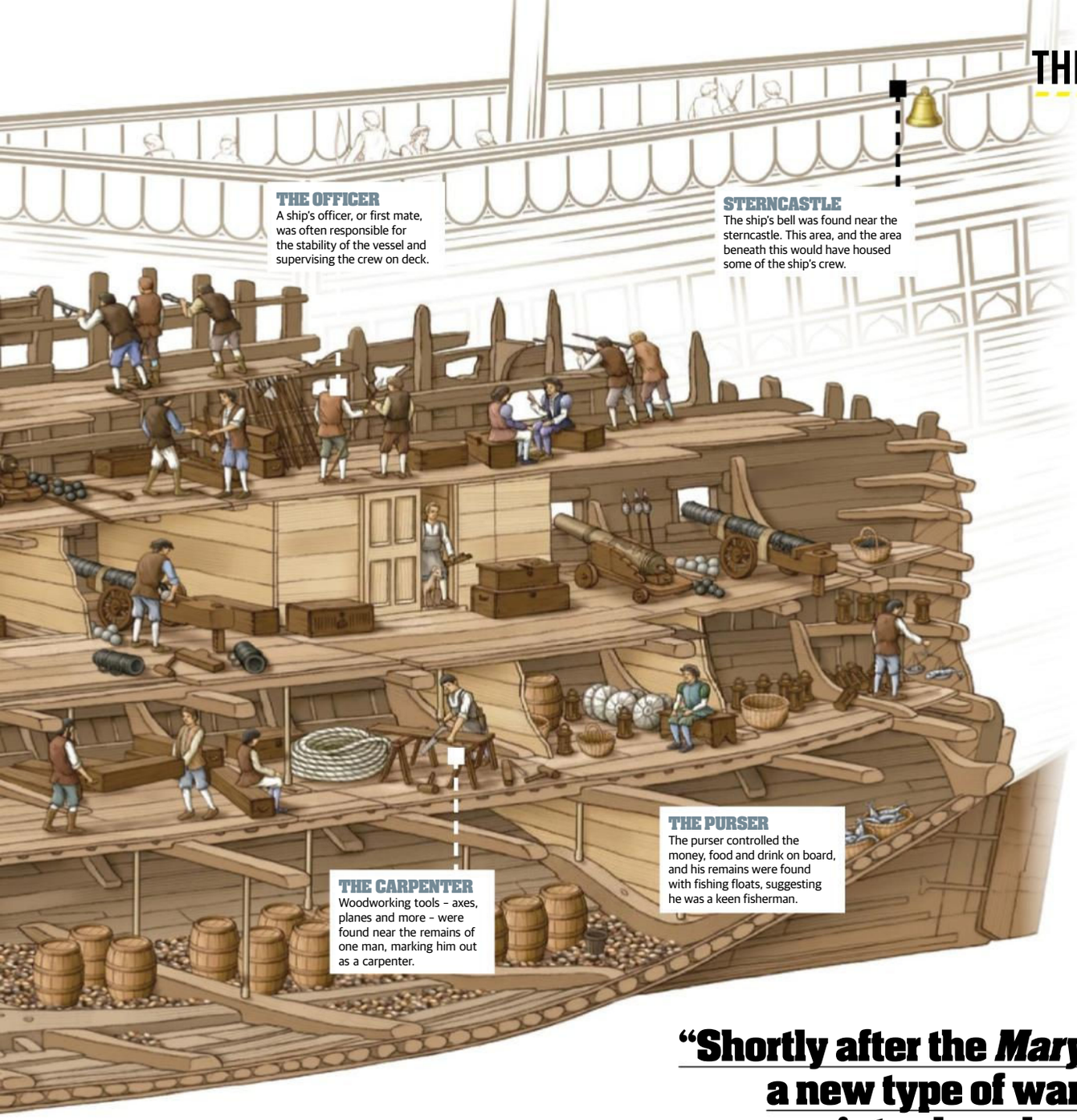
The picture this paints of the last hours of the men on board is one of chaos, panic and hopelessness. A picture of a crew sunk by their own disobedience, and a general lack of understanding between the crew on board. But, levels of illiteracy were perhaps surprisingly high among men at this time, and particularly among the ambitious and somewhat 'upwardly mobile' profession of sailing.

Around 20 per cent of the male population was literate according to a study of education when Elizabeth I took the throne in 1558. The discovery of artefacts found on board bearing letters – for example, a knife handle and a trencher bearing the letter 'W' and a spoon bearing a reversed 'N' – goes further to suggest that the men on board were at least able to read the alphabet. But, as is often the issue with drawing conclusions about the *Mary Rose*, we cannot truly know the levels of literacy or competence among the crew.

Finally, Dr Marsden states, one last inconvenience would become a catalyst for the ship's demise: "The inefficient and slow system of closing gunport lids forbade making an immediate response to heeling over," and so once the water had begun gushing in to these ports, there would be no chance of stopping it – or of stopping the ship from sinking.

Questions like this one of the fitness of the design of the ship lead to another route of inquiry – should more have been done to make the ship safe for the crew? Was the safety of the crew even a consideration for the war-mongering king or the ship's designers and builders?

Dr Marsden told us, "Of course, safety was a vital consideration in the period, but as the technology



FACTS

10,000
Approximate number of artefacts found on the shipwreck

25
Estimated number of crewmembers that survived

34 YEARS
Mary Rose served as Henry VIII's flagship

£133,000
Money spent on flags for the ship (in today's money)

600
Number of tons *Mary Rose* weighed when she was made

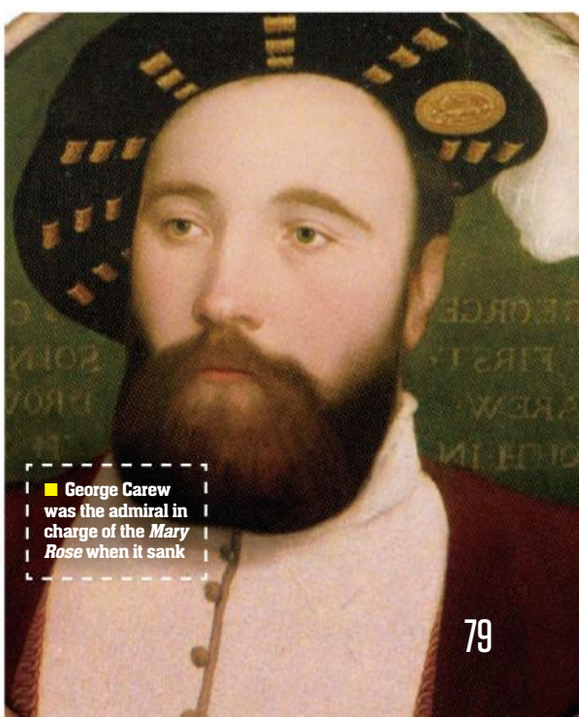
"Shortly after the *Mary Rose* sank, a new type of warship design was introduced – the galleon"

of warfare at sea was pushing ahead quite fast, there were vulnerable areas of danger on board that had not been addressed.

"For example, the system of opening and closing the gunport lids on the main deck was operated by men pulling ropes on the upper deck, rather than, as in later times, by the main deck gunners themselves, as can be seen on the *HMS Victory*." This would have meant that communication would have been difficult, sight may have been impaired as the gunport lid operators were further from the equipment they were dealing with, and any problems would take longer to fix. Considering the prevalence of the slow closing of the gunports as a cause in the ship's sinking, the operation of lids by men on the main deck was a simple innovation that came far too late for the *Mary Rose*.

Another cause for concern was the use of what were effectively 'trap doors' located around the ship's deck, inviting disaster as the men went about their daily business. Dr Marsden, who has spent significant time with the wreck's remains, made the point that "the hatches along the middle of each deck had no gratings, but simply wooden covers. This meant that when a hatch was left open for access, in the dim light below a man might not notice the hole in the deck and could fall and break a bone." It might seem an obvious hazard, particularly by today's highly regulated health-and-safety standards, but in the 16th century, it was par for the course.

However, things were soon to change. "There were other problems, but shortly after the *Mary Rose* (a type of warship called a carrack) sank, a new type of warship design was introduced – the galleon. This solved many of the problems," Dr Marsden told us. The galleon improved upon the carrack in many ways – carracks were wide and



George Carew was the admiral in charge of the *Mary Rose* when it sank

unwieldy to steer by comparison, while galleons were narrower and longer, which contributed toward making their handling much smoother. Carracks were also most often designed with 'castles' at, or even overhanging, the bow and stern of the ship, which were raised areas above the deck and were used for work or combat. Galleons, on the other hand, are flush-decked, with any castles located further into the deck area, allowing for a longer, triangular stern, making them more aerodynamic and easy to steer.

As the *Mary Rose* came just before a watershed change for the design of seaships, it is, for this and many reasons, incredibly useful for archaeological purposes. It is almost unique in its level of preservation and in the fact that it was raised from the seabed in 1982, and has been diligently preserved ever since. Its close proximity to the English shore and its impressive levels of underwater preservation make it perhaps our most comprehensive insight into Tudor life, and life at sea, in the 16th century.

While there is plenty of mystery surrounding the ship, it has also helped demystify a great many aspects of the period for historians. As all of the men aboard died on the same day, for the same reason, it provides a rare snapshot of a particular set of people (in this case, a particular profession) at a specific time. Their dental remains have also been incredibly useful for creating a fuller picture of what people ate at the time - one set even had traces of seeds that allowed analysts a specific view into what one man ate on the very day that he died.

Inspecting the remains to this degree may seem somewhat intrusive, disturbing the earthly remains of hundreds of the men who sank with their ship and likely expected to decompose at the bottom of the sea for eternity. But as with most archaeological endeavours, the results arguably outweigh any ethical doubts. 92 of the skeletons found were almost complete, giving unprecedented insight into the physique of seamen of this time. And the analysis hasn't slowed by any means in

The salvage of the *Mary Rose* was a truly momentous occasion

'HATCH' THE DOG

The prevalence of rats on a Tudor ship called for a domesticated animal to keep the numbers in check. While it may traditionally be thought of as a cat's job, the Mary Rose, and other ships like it, employed a dog. We know this as the remains of the dog, nicknamed 'Hatch', were found with the ship.

Rats are often too big for cats to catch and kill, and those aboard ships were notoriously fierce, making dogs a far more suitable choice to keep the pests at bay. To add to this, Pope Innocent VIII had declared cats unholy in 1484, as a result of their reputation as complicit companions for witches, which contributed to their being considered 'unlucky'. This opinion died out in England some 200 years later.

Analysis revealed that the dog was male and an early form of terrier – though breeds as we know them now would not have existed in the same way until after 1545. He was between 18 months and two years old when he died, and had a brown coat. He was by some way the youngest member of the crew (though some of the remains were identified as being 13 years old).

To determine these fascinating details about the ship's canine companion, DNA was taken from one of Hatch's teeth, and was analysed by experts from the University of Portsmouth, the Royal Zoological Society of Scotland, the Royal Institute of Technology, Sweden, King College London Dental Institute, Durham University and the Mary Rose Trust.

They also discovered that Hatch had suffered from a hereditary disease called hyperuricosuria, a defect which causes kidney and bladder stones. It was previously thought to be the result of inbreeding in modern breeds, but this may be evidence of its prevalence before the intensive breeding of dogs.

the two decades following the raising of the wreck: researchers continue to look into the blood groups, DNA information and the bone characteristics of the remains today. In doing so, they have identified the remains of the ship's archers, through identifying a particular bone condition, members of the gun crew identified by ossification (new bone, grown later in life) as a result of heavy work, and the purser, characterised by the chest of gold and silver coins he was trapped in his cabin with when the ship went down.

Dr Marsden understands well the significance of the archaeological findings on the *Mary Rose* and told us, "The whole collection gives us a unique view of life on board one of the largest ships of the early permanent Royal Navy." But which of the finds does he find the most illuminating?

His choice illuminates a particularly fascinating conundrum in identifying the remains of a specific person aboard the doomed vessel: "If you really push me to find one item more exciting than the rest, it is a group of silk buttons found with a skeleton in the collapsed sterncastle. Only noblemen were allowed by law to wear silk costumes, so it seems likely that the remains of a nobleman were found." The proximity of the buttons to the remains almost entirely marks them out as belonging to each other, and so it would indicate that the skeleton is that of one of the only men aboard that we can actually name today.

"The whole collection gives us a unique view of life on board one of the largest ships of the early permanent Royal Navy"

"Only two are historically recorded as being on board: Sir George Carew and Sir Roger Grenville," Dr Marsden told us. "Maybe a DNA study will in future tell us exactly who he was – as was done to identify King Richard III."

One of the most significant finds on the wreck was a collection of 137 complete longbows, and thousands of arrows, the first such examples to be found intact, offering military historians a startling insight into the importance of longbows and archers in warfare at the time. Analysis of bones revealed that some of the men had developed a bone condition called os acromiale, which affects the shoulders and is still found in modern professional archers, so the remains displaying this condition can fairly certainly be identified as archers on the ship.

In their quest to further understand the use of longbows aboard the *Mary Rose*, scientists and historians (and the well-known English actor Robert Hardy, as the country's most experienced longbow expert) performed many tests on some of the longbows that were found preserved – testing their flexibility and force, to breaking point in some cases. With such a large number of unprecedented exhibits, they were able to fully test the capabilities of this Tudor weapon without too much concern for breaking a specimen in the name of research, and found that the weapons had draw weights of up to an incredible 82 kilograms.

It is exactly this sort of discovery – of which there have been so many since the ship was raised from the seabed – which makes the *Mary Rose* such a fantastic historical paradox. Never has a shipwreck answered as many questions about the period it sailed in as the *Mary Rose* has, nor has any shipwreck left quite so many mysteries unsolved. While it may not have been much comfort to the men who died, seemingly without real cause and perhaps at the mercy of a simple gust of wind, the passage of time has made their deaths remarkable indeed. Without them, we might have a very different picture of the lives of 16th century seamen, and Tudor life as a whole.

THE HAITI EARTHQUAKE

In 2010, an impoverished nation used to adverse tropical weather was struck by an earthquake that brought it to its knees

March 2008. Five scientists are attending the 18th Caribbean Geological Conference in Santo Domingo, Dominican Republic. The gathering of minds, which comes together to discuss everything from seismic activity to the production of hydrocarbons, is always a colourful experience due to the lively geological nature of the Caribbean. But these five men aren't here to share good tidings. Their research has produced some frightening results and they've come to the Dominican Republic not just to share their data, but to try to convince authorities that something terrible is stirring: Hispaniola's two major east-west trending strike-slip faults, the Enriquillo-Plantain Garden Fault in the south and the Septentrional Fault in the north, are due for a major seismic event.

Using a series of GPS readings, the team predicts the region will suffer an earthquake on a magnitude of 7.2. The faults also run beneath the Haitian city of Port-au-Prince, meaning the most populated locale in the region would endure the very worst of the quake. The news worsens when the team reveals that the seismic tantrum could kick off at any moment, a ticking geological time bomb primed to explode with little or no warning. The findings don't fall on deaf ears – in fact, representatives from the Haitian government meet with the scientists to discuss their data but the fact remains Haiti simply doesn't have the time, or the resources, to build any sort of protection for its citizens.

Unlike Japan – which began reinforcing buildings and conducting regular earthquake drills following the devastating event in Tokyo in 1994 – Haiti is simply too poor a nation to be able to erect any kind of meaningful defence. "We had talked to a number of government officials about the risk and they were very receptive. They just didn't have enough time to do much to prepare for such an event, especially with Haiti's other pressing problems," recalled Eric Calais, one of the members of that team and a geophysicist at Purdue University in West Lafayette, in a 2010 interview with *Earth Magazine*.

Before that fateful day in 2010, Haiti was no stranger to the trials and tribulations of tropical weather and geological activity. Those "pressing problems" were numerous and constant. Between 2001 and 2007, tropical cyclones and floods left more than 18,000 dead and 132,000 homeless, with approximately 6.4 million people affected (the total population of Haiti is about 10 million). During the 2008 Atlantic hurricane season alone, Haiti had been rocked by Tropical Storm Fay, and Hurricanes Gustav, Hanna and Ike, all of which hit the country within a month. This cabal of tropical events left over 800,000 people displaced.

The populous city of Port-au-Prince, the rest of Haiti and the island of Hispaniola as a whole is one of many ecological punch bags that continues to soak up the blows thrown their way. This nation had known hardship its entire life, from the bloody grip of the French slave colonies to the realities of sustaining itself following independence (gang violence had been a serious issue since the 1980s), so Haiti already had a bloody nose when the plates beneath the region shifted.

As Port-au-Prince and the rest of Haiti begins to wind down after a long day on 12th January 2010, its positioning above the North American plate to the north and the Caribbean plate to the south comes into play. These two plates are slowly shifting past one other, as the Caribbean plate moves from west to east. Between them lies a set of interconnected fault lines that pass through Haiti – the first, the Enriquillo-Plantain Garden Fault, runs through the south of the country, while the Septentrional Fault runs through the north. This creates an unusual geological composition known as a 'strike-slip' fault – similar to the San Andreas

IN BRIEF

- **Death toll: 316,000**
- **Port-au-Prince, Haiti**
- **12th January 2010**

Haiti was not prepared for the 7.0 magnitude earthquake that struck on 12th January 2010. As a poor nation, Haiti was unable to withstand the shock of impact.

Fault that runs beneath California – meaning the plates slide horizontally past one another, rather than one slipping under the other.

There's very little warning before the quake kicks into action, most of which comes down to the fact very little research of the region and its geological makeup has been performed prior to the 2010 quake. Scientists simply didn't have enough data to predict when the event would occur, only knowing that it could happen at any time. So when the quake strikes, there's little time for evacuation.

At 4.53pm, the earthquake hits with full force. The day is drawing to a close, but the streets are still full of people, the roads still full of cars and traffic. Buildings across the city of Port-au-Prince start to shake with a terrible violence. Glass windows instantly shatter, raining razor-sharp shards onto the streets below. Walls crack and crumble, collapsing in on themselves as the very earth beneath Haitian feet spasms with a terrifying intensity. On the hills surrounding the city, buildings as high as nine storeys crumble inwards and begin flattening down the elevation, creating a wave of concrete and rubble.

Car alarms ring everywhere. Screams and cries of panic fill the air. Entire concrete walls are ripped from where they previously stood and thrown like strips of paper against other structures. The quake doesn't cause any surface rupture (large cracks or chasms in the ground near a quake's path of destruction), but the shaking registers with an intensity of IX on the Modified Mercalli scale (MM). In a country that doesn't use any sort of building code (meaning people can erect houses anywhere and build them however they wish, regardless of how unsafe such methods might make them), Port-au-Prince is shaking to its core. Among the remains of gutted homes, bodies lie everywhere.

As the quake subsides and the aftershocks commence, the race to react begins. The response from the government remains thin on the ground, with water trucks appearing to bring clean water to the survivors and ferries organised to ship people away from Port-au-Prince to nearby shelters in Port Jeremie and beyond. It's a point of contention that leads to vocal protests in the days to come, but here and now in the heart of the disaster, it's the international humanitarian response that touches down in the hours that follow. The United Nations Security Council sends 3,500 troops and police of the United Nations Stabilization Mission via Resolution 1908. The USA, the UK, Israel, the Dominican Republic, Canada, Brazil, Italy and Cuba are just some of the many countries that send thousands of troops to help in the rescue efforts.

The international community, realising that Haiti simply doesn't have the economy to mount and sustain a full-scale response, begins releasing huge amounts of relief aid funds to help fund what becomes a truly global response. The EU releases €3 million in emergency funds to fuel the initial response, followed up by €122 million in humanitarian assistance. It even releases another emergency relief aid package of €30 million to ensure there's enough food, medicine and qualified boots on the ground to save those trapped and protect those that have survived the disaster.

For Philippa Young, head of Emergency Food Security and Vulnerable Livelihoods at Oxfam's Global Humanitarian Team, experiencing the chaos

THE EARTHQUAKE OF 1770

The 2010 earthquake was one of the most catastrophic natural disasters ever seen and proved a stark reminder of just how much destruction a quake could unleash upon coastal towns and cities. But for its horror and magnitude, this was not the first time the Earth had shaken Haitian soil to its core.

Back in 1770, Haiti was still a French colony under the moniker of Saint-Domingue and most of the population were slaves based around what would become the Haitian capital, Port-au-Prince.

When the 8.0 magnitude earthquake struck at 7.45pm on 3rd June, the result was catastrophic. The force of the quake was so strong it liquefied the soil beneath Port-au-Prince, causing practically every building to collapse as the ground shifted into a hellscape. About 250 people were killed as the city was reduced to rubble. Even those structures that had survived a smaller earthquake in 1651 were torn down as the colony was crippled in a matter of minutes. One village, Croix des Bouquets, was struck so hard it sank below sea level. A tsunami also hit the island shortly after – however, a distinct rumbling prior to the quake enabled a great deal of the population to flee before the first tremors began.

While the death toll of the event itself topped off about 250 souls, the aftermath that followed claimed far more. The collapse of Port-au-Prince enabled thousands of slaves to escape captivity, throwing the entire region into chaos. The fragile economy established by French colonists effectively collapsed, leading to a catastrophic famine. In the ensuing months, over 15,000 people would die of starvation. It would prove to be the most terrible natural phenomenon to strike the region until almost 250 years later.

A US Air Force pararescueman from the 23rd Special Tactics Squadron helps rescue a woman trapped in a collapsed building

"Despite all the death and destruction that lies across the city, the Haitian people aren't broken by the disaster"

first-hand revealed just how severe the damage to Haiti really is. "I arrived about ten days after the earthquake," she explained. "Everything was still very chaotic. Bodies still hadn't been fully cleared away; damaged and destroyed buildings were everywhere. Our guest house had a big crack down the side. There were about 40 of us camping in the garden of the guest house, all queuing for toilets and showers and such. Banks were closed and security was very tight so we were totally reliant on the office to provide food for us. A makeshift canteen was put together serving over 100 people a day and it took a while to get going properly. In the beginning breakfast was something quick at six-ish and lunch wasn't served until about three. We didn't really notice the hunger though as everyone was running on adrenaline."

Despite all the death and destruction that lies across the city, the Haitian people aren't broken by the disaster. In fact, Young witnesses an inspiring sense of unity and remembrance while everyone works to clear the rubble and rescue trapped citizens. "Two of the office staff were killed in the earthquake and a few days after I arrived, there was a memorial to them which was lovely," remarked Young on her experiences in the aid effort in 2010. "All the Haitian staff sang local songs and everyone held hands while they thought about them. It was highly emotional and I had to go and hide in the loo to cry after it had finished.

"The Haitian national team were amazing - full of energy and eager to get things done," she added. "Our local partners were very keen to work with us and needs were extremely high everywhere we looked. We knew we had to get aid out asap and were trying to work out the best ways of doing this though some emergency aid had of course already started. Makeshift camps were everywhere. Thousands of people were living in tents on the main golf course and on any space they could find."

That sense of unity runs through the whole of Port-au-Prince and the surrounding areas. A terrible calamity has struck the region, one that many have endured before, but that doesn't mean it's left them broken or lost. Haitian citizens fill the streets, working together to clear rubble and bodies, carrying supplies and medicine to those that need it, comforting one another with songs and words

EXPERT OPINION

Dr Luc Herby Mesadieu, senior manager Program & Support, HelpAge International Haiti

What were conditions like when you arrived?
I started with HelpAge in April 2010, right after the earthquake, and conditions in the country, especially in the metropolitan area, were catastrophic. The population affected was living in a very difficult situation without access to basic needs. This situation affected most of the older people, who are among the most vulnerable group and being overlooked by the emergency responses. Most of their needs were related to health – more specifically, a lack of specialist care for older people in Haiti. Also, the inconsistency of age-specific data collected has limited a widespread direct response to older people's health needs. Older people were also abandoned in camps, presumably in acts of desperation by family or community members. Without livelihoods, without creative and well-planned income generation strategies, older people have been forced to rely solely on family and community members.

How do you decide what aid is needed where? Is there one system applied to all cases or a general idea that is then adapted?
At the first phase of the response, we tried to address basic needs like food, access to water, health care and distribution of non-food items. But rapidly with the help of HelpAge staff, older people living in camps organised themselves and started creating older people camps associations and homebase careers. HelpAge International meet with those structures to assess needs in order to better adapt the response. Each association had their specific need in function of the locality where they live. It was not one system applied for all cases as we had provided personalised assistance and needs base. For example, older people that were living in rural areas did not have the same needs as older people living in urban areas.

Do you think it took too long for conditions to improve, or did the disaster and the conditions before the earthquake mean it would always take a long time?
It would always take a long time for conditions to be improved. Haiti is vulnerable to natural disasters and also there was a precarious economic situation and political instability. The disaster worsens the situation, but we have hoped that it was an opportunity to rebuild the country. Up to now, Haiti is facing food insecurity; vulnerable people are still living in camps; health access is very limited; most people cannot access basic needs.

HAITI IN RECOVERY

When an earthquake of the magnitude that struck Haiti arrives, any coastal city on Earth would find itself wounded from the encounter. From destroyed residences to endangered nuclear power plants, an earthquake can destabilise or merely fracture a nation in its wake. For a country as poor and underdeveloped at Haiti (which ranks as the poorest nation in the Western Hemisphere, ranking 149th out of 182 countries on the Human Development Index), rebuilding lives and livelihoods can seem as insurmountable as the actual event itself.

According to the International Organization for Migration, around 94 per cent of the displaced citizens in Port-au-Prince have left camps and other temporary sites. However, a good 80,000 Haitians are still without, "a proper roof over their heads," spread across the country's remaining 105 camps. Despite this, Haiti is beginning to rebuild itself, albeit at a steady pace. While a few wrecked buildings still remain in the capital, almost all rubble has been cleared away. The famous Iron Market that was destroyed back in 2010 has been replaced with a colourful new one and a clock tower.

Tensions continued to rise when an outbreak of cholera rocked the nation in the months following the earthquake. The epidemic, which has claimed the lives of 8,000 Haitians so far, sent an already crippled country into a nationwide health scare and created serious divisions between Haitians and relief forces. The US government claimed United Nations forces were the ones who had brought the contagion to Haitian soil, a claim the UN refuted.

An investigation that followed revealed a UN peacekeeping base near the Artibonite River (a body of water that provided drinking water and hydroelectricity for Haiti and the surrounding areas) had become contaminated. The UN denied it had caused such contamination, but further tests proved the strain of cholera originated in South Asia, adding further weight to an outside source bringing it to Haiti.

of hope. There's death all around, it's impossible to ignore, but there's life too, and an enduring sense of hope in the face of such intimidating adversity.

Those humanitarian forces have a huge amount of work to do in the aftermath of the quake. With over 3.5 million people affected by the event, ranging from the many killed by the tremors to the businesses and livelihoods disrupted by the aftershocks, work begins to erect tented camps in areas safe from fallen buildings. With the aftershocks finally subsiding, there is a startling 19 million cubic metres of rubble and debris in Port-au-Prince – enough detritus to fill a line of shipping containers stretching end to end from London to Beirut. In total, 60 per cent of government and administrative buildings, 80 per cent of schools in Port-au-Prince (roughly 4,000 sites of education) and 60 per cent of schools in the South and West Departments have been destroyed or damaged.

So where do you start as a humanitarian force? How do you prioritise your manpower and resources when so many people have been affected? That's a question Young and her fellow relief workers at Oxfam had to consider when they arrived in Haiti. "An organisation like Oxfam will have a generic idea globally of the sort of vulnerability criteria that it could use but this of course needs to be massively adapted to a local context and depends on the severity of a disaster," she revealed. "In Haiti, everyone had been affected – the very poor had become utterly destitute, the poor who might have scraped by previously now had no options. People who would have had reasonable income earning potential, tradesmen, shop owners and such, also lost everything with no hope of recuperating this by themselves."

That combination of location, depth, severity and lack of earthquake proofing created a maelstrom of problems for both the Haitian government and the international teams that arrived in the hours after the initial quake. Accessing every area proves a serious issue, especially by road as most are strewn with rubble and bodies, a great deal of which has slid downhill from those homes that once stood on the hills surrounding Port-au-Prince. Roads in Haiti were poor to begin with, now most are impossible to traverse. This means there is a greater reliance on air support, a resource that's both expensive and difficult to organise across such a vast affected area.

"Poverty and living conditions were often terrible even before the earthquake, so it was difficult to distinguish general poverty from overall

"The very poor had become utterly destitute, the poor who might have scraped by previously now had no options"

Citizens are evacuated from Port-Au-Prince on ferries

FACTS

7.0 The precise magnitude of the 2010 earthquake

Death toll figure presented by the US Geological Survey

100,000

160,000 Larger death toll figure presented by the University of Michigan in 2010

3.5 MILLION The number of people estimated to have been affected by the quake

52 The number of aftershocks detected after the initial quake in 2010

16:53 The time at which the first tremors struck Haiti

earthquake-related needs," recalled Young on her time helping the survivors of the disaster. "Security was also an issue, though this has improved in recent years. There were no decent construction standards in place and as people had lived in slums, they didn't own the land to begin with. This made it impossible to just start rebuilding houses because first; they weren't typical houses to begin wit. Second; if they did they were possibly illegal and third; there were no real decent construction companies to be trusted to rebuild."

So why did this particular earthquake, centred in a region that had seen dozens of quakes of this magnitude over the years, conjure so much destruction? The answer lies in three very important factors that coalesced on that fateful day. The epicentre of the quake had been just ten miles southwest of Port-au-Prince - rather than being far out at sea, the quake's origins were instead terrestrial. This prevented the creation of a tsunami (or at least one powerful enough to cause much damage), but its proximity to the people of Haiti going about their daily business was catastrophic.

The second factor that amplified the destructive power of the quake relates to depth. By rumbling at a depth of 10-15 kilometres below the surface, the quake's brutality wasn't dampened by travelling through the layers of the Earth. Considered 'shallow' by the United States Geological Survey, the 2010 Haiti earthquake was not only close to Haiti's most populous city but was primed to attack with little or no geological dilution. The final issue related to the roadblock encountered by the scientists at the 18th Caribbean Geological Conference in 2008 - Haiti's government simply didn't have the infrastructure or the economy to support region-wide protection against quakes.

Five years on, Haiti is still very much a nation in recovery. Despite the economic support provided by the United States, Europe and the rest of the developed world, the small nation is still struggling to 'better' itself in the wake of its worst ecological disaster in living memory. A total of $13.5 billion was pumped into Haiti to fund the relief effort and help kick-start the country's economic rehabilitation, but with ongoing political in-fighting within Haiti's government and a general sense of distrust that's grown since the outbreak of cholera (a disease that had never touched the island prior to 2010) has made seeing true improvements, such as ensuring new buildings are earthquake proof, a near impossibility at this stage.

Haiti remains a nation full of hope for the future, but that doesn't change the danger that still lies beneath its soil. As a geological hotspot for seismic activity and ecological nightmares, Haiti and the surrounding areas will no doubt endure more of these events in the future. As a country with a rich sense of culture and a people who found a sense of hope even in the darkest of hours, we can only hope it will be better prepared when that inevitable 'next time' arrives. For more information on Oxfam's humanitarian efforts in Haiti and around the word, visit bit.ly/2a9pTr7.

IN BRIEF

- **Death toll: 6 (verified)**
- **London, UK**
- **2nd September 1666**

In four days the fire gutted the City of London, destroying thousands of homes and displacing many thousands of people. The rebuilding of the city took years.

THE GREAT FIRE OF LONDON

In a city pushed to breaking point, the smouldering coals from a bakehouse devastated the heart of England

Deep in the early hours of Sunday 2nd September 1666, the plague-stricken and drought-ridden City of London was changed forever. In an unassuming and unremarkable bakehouse on Pudding Lane, as the baker and his family slumbered, a fire started that would blaze for days.

Within minutes, the flames had built into a nightmarish inferno and the stage was set for one of the most important events in the life of Restoration England. The Medieval lanes and alleyways that made a labyrinth of the City of London filled with fire, timber and thatch – feeding the flames that lit up the sky for three long, devastating nights. The Great Fire of London wreaked havoc, seemingly unstoppable, until it was finally brought under control on Wednesday 5th September.

When the flames died to embers and the smoke cleared, the City of London was left in ruins. Although official casualties were surprisingly few, there was no such mercy for the buildings squeezed into the tightly packed streets. Crowded wooden tenements were reduced to ash and tens of thousands were made homeless and left with nothing to their name.

In the aftermath of the fire, scapegoats were sought and found, and an innocent man went to the gallows. For those who followed a different faith or came from overseas, this was a time of suspicion and distrust. So dark did things become that the king himself dispatched troops not only to fight the fire, but to save those who had, for one reason or another, attracted the attention of the mobs who crowded the streets, calling for justice.

As days turned into weeks and weeks into months, the process of rebuilding London became the primary focus of Crown and parliament. From the rudest tenement to the great Cathedral of Saint Paul's, the buildings that had been swallowed by fire were painstakingly replaced with new structures. It was a time of change, with famed names like Sir Christopher Wren reshaping and building the foundations of the city that we know today.

At the dawn of 1666, the great metropolis of London was the largest city in Great Britain. More than 500,000 people were packed cheek by jowl into its sprawling buildings, the city expanding far beyond its original confines until the slums spilled out of the city walls. London had been a centre of commerce, trade and civilisation for centuries and it was growing at an unprecedented rate. People from all over the world came to live in the city, creating a cosmopolitan, and sometimes confrontational, melting pot.

Home to about 80,000 people, the vast majority lost not only their accommodation to the inferno, but virtually everything they owned. Packed tightly into the unyielding city walls and with the mighty River Thames forming a natural boundary to the south, the Medieval founders of the City of London had not envisioned such a vast number of inhabitants when they laid out the city.

London was a maze of twisting, narrow alleyways that rarely saw the sun, its residents deprived of fresh air or basic sanitation. As the centuries passed, it had grown and developed, unplanned and virtually unregulated despite efforts to increase restrictions on what could be built and where. Instead, buildings were seemingly dropped down anywhere, no sooner finished than they were already filling with residents desperate for a roof over their heads.

"This forest of tottering wooden tenements with dry thatched roofs provided fertile kindling for the hungry fire"

This forest of tottering wooden tenements with dry thatched roofs provided fertile kindling for the hungry fire. Although combustible materials were supposedly prohibited, stone was expensive, while wood and thatch was cheap, so builders took a risk, regardless of regulation. As the overcrowding grew worse, those who could afford to began to move out of the centre of the city. Estates were set out, the large stone houses of the wealthy surrounded by open ground, but for those who could not afford to escape, the future was bleak.

Suburbs and slums sprang up quickly and the vast majority of the population settled in these ill-maintained buildings. With so many people living in squalid conditions, the conditions were rife for catastrophe and the plague took a devastating hold on the people of the City of London in 1665. The rich had no desire to be in the centre of this crowded, stinking swarm, and even though they maintained their spacious, fine city residences built of strong stone, they often left the seething streets of the capital far behind them in times of plague. For those with money, there was another world far beyond the slums.

Here, in the fresh rural air, the wealthiest people settled in their country retreats when the working week was done, while King Charles II made his court in Westminster. Interestingly, his palace came perilously close to being devoured by the flames that consumed so much of London. In fact, the king's initial efforts to help extinguish the flames were rebuffed, while personal and political prejudices contributed to the spread of the inferno and the scale of the damage that was wrought in such a short amount of time.

The Great Fire as seen from a boat in vicinity of Tower Wharf

London in the autumn of 1666 was dry, dirty and dusty, no rain having fallen in ten long months. In the plague-ridden city, the wooden tenements were just waiting to go up in flames. When night fell on Saturday 1st September 1666, baker Thomas Farriner closed his Pudding Lane bakery and went to bed. As he slept, the bakehouse coals he had thought safely extinguished caught light, and before long the ground floor of the Farriner bakery was ablaze.

With flames blocking the exits, Farriner, his family and their servant fled across the rooftops. Behind them they left a maid who was too afraid of heights to follow. That anonymous, terrified girl was the first casualty of the Great Fire of London.

Strong winds blew embers and flames out into the streets, igniting the sun-bleached buildings and hay bales. As the watch rallied to the cries of "Fire!" they decided to create a firebreak by demolishing neighbouring buildings. Residents refused to give consent and with stalemate reached, the lord mayor, Sir Thomas Bloodworth, was summoned to the scene.

When Bloodworth arrived, he refused to exercise his right to demand the demolition of the buildings. Without the permission of the king, the City of London would have to bear the cost of rebuilding, and he wasn't about to take on that expense. Perhaps Bloodworth believed this was just one more fire among the many small blazes that often burned in the city, but such beliefs would be proven catastrophically wrong.

Its infernal progress seemingly unstoppable, once the fire hit the dockside and the highly combustible cargoes stored there, all chances of extinguishing it quickly were lost.

As the night sky turned red, diarist Samuel Pepys left his home and travelled by river to see the extent of the fire. He watched as the city went up in flames, churches and slums alike consumed by the inferno. Pepys recorded the progress and aftermath of the fire in his diaries, lending a unique first-hand account of that infamous time. Through his eyes we see Bloodworth falter, the royal family flourish and the people panic.

"Strong winds blew embers and flames out into the streets, igniting the sun-bleached buildings and hay bales"

Fleeing before the raging conflagration, Londoners tried to save what they could. They hurled their belongings into boats and handcarts or even into the river. Soon the hot, narrow streets were an impassable tide of the dispossessed as thousands of people fled for their lives. Firefighters couldn't break through the panicked mass and the king, far from safe in his palace, took action.

Charles II gave the order to tear down every building in the path of the fire, hoping to stop it with firebreaks. Still the blaze spread and by Monday, the north bank of the Thames was alight, London Bridge was aflame and Southwark was threatened by winds lifting embers over the river. The spread of the fire into south London was stopped by a firebreak on the bridge, yet in the city there was no such luck. A firestorm engulfed the Royal Exchange, the middle-class homes of city professionals and all that stood in its way.

As civil unrest threatened, the king put his brother, the Duke of York, in charge of dealing with the fire. York took charge of the controlled demolitions, and his troops were dispatched to quell unrest in the streets. Stories tell that Charles II himself came into the city and pulled down buildings, throwing water onto the flames as everyone that could help did their bit.

By the time Saint Paul's Cathedral fell, pouring moulten lead into the streets, it must have seemed as though the world was ending. Should the firestorm reach the Tower of London, the gunpowder stored there would go up like a bomb, and houses between it and the flames were demolished with explosives, creating a firebreak.

As the wind fell on Tuesday night, the firebreaks had finally started to do their job. The raging flames now died down, leaving thousands homeless, terrified and utterly lost in a London that had become unrecognisable.

DID THE GREAT FIRE REALLY WIPE OUT THE PLAGUE?

The old story that the fire put an end to the plague is hard to sustain. Mortality rates were already falling by the beginning of 1666. The king felt it safe to return to Whitehall Palace on 1st February. Catherine of Braganza followed him ten days later. True, the plague was far from over. Playhouses remained closed; the annual Bartholomew Fair at Smithfield was cancelled "for fear of a renewal of the contagion," and all through that August, reports of the epidemic poured in from around the country: "In Northamptonshire the sickness rages extremely, especially in Peterborough, Oundle, and Newport Pagnell, in which last, though a market town, only 700 or 800 people are left. At Cambridge it is so sore that the harvest can hardly be gathered in."

On the Kent coast, the situation in Cinque Ports was desperate. By the end of the month, three-quarters of those who had stayed in Deal and risked infection were reported to be dead; Dover and Sandwich were affected; and the plague had also moved inland to Canterbury as well as Maidstone.

Surely the very fact that the plague wasn't confined to London demonstrates that the Great Fire could not be responsible for eradicating it? Put at its simplest, the capital wasn't the only source of contagion.

FACTS

The fire burned at
1700°C

2/3RDS
of London Bridge was burned, saving Southwark and the city south of the river

The fire burned for
3 nights
6 deaths
were recorded

The monetary cost of the fire was
£10 MILLION
more than
£1 BILLION
today

13,200
houses were destroyed

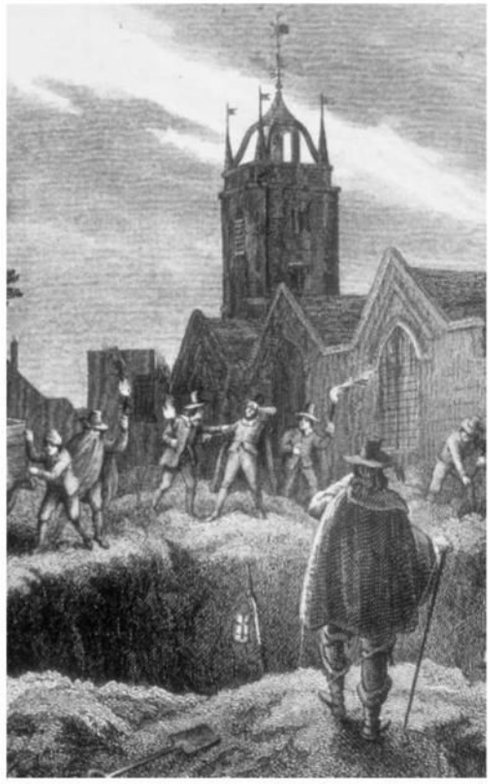
Over
70,000
left homeless

"Those who lost everything to the flames found that surviving the inferno had only been the beginning of their woes"

On 5th September 1666, as the remains of the City of London smouldered, it finally seemed as though the worst was over. Though the immediate danger had passed, cleaning up in the aftermath of the inferno would take years.

The devastated city was shrouded in smoke, small fires still burning here and there among the ruins, bright and hot amid the ash. Enormous numbers of casualties were expected, yet when the toll of the dead was counted, it was, unbelievably, just six, certainly less than ten. Of course, this accounts only for those whose remains were found. The fire burned so hot and through such tightly packed areas that it's possible many others, particularly the infirm, old and very young, were completely cremated and lost among the ashes of their homes. We can never know the true human cost of the fire, though if it was truly just six, it's nothing short of miraculous. For the survivors, there were to be precious few miracles in the days to come – tens of thousands of people left with nothing as a harsh winter fell over the City of London. In the months that followed the Great Fire, those who lost everything to the flames found that surviving the inferno had only been the beginning of their woes. Now they began to fall victim to rampant disease, or the bitter cold and starvation, not to mention the mobs seeking foreigners and seditious traitors to lynch.

Baker Thomas Farriner, in whose bakehouse the fire had started, was quick to point the finger elsewhere. He claimed that he wasn't to blame, and wasn't about to be hung out to dry. Instead, Farriner was determined that someone else should bear the responsibility for the catastrophe that roared through the city, and there was no shortage of candidates. The search for someone to blame began in earnest before the fire was extinguished, and that search would lead an innocent man to the Tyburn tree.



London Bridge becomes a shelter for terrified citizens

Perhaps the most tragic story to come out of the Great Fire of London is that of Robert Hubert, a simple-minded young man with a habit of confessing to starting fires that had nothing to do with him. Hubert died on the famous Tyburn Gallows after he confessed to having firebombed the bakery. He claimed that French Catholics in

"Anti-Catholicism was rife and rumours spread quickly"

the employ of the Pope himself had paid him to commit the crime but now his conscience had forced him to confess. Hubert was entirely innocent, of course, and after his death it was discovered that he had not even been in the country on the night of the fire, but had been at sea. Yet anti-Catholicism was rife and rumours spread even quicker than the fire that conjured up papist conspiracies and suspicion.

King Charles II invited proposals for rebuilding the shattered city and he received them in abundance, ranging from the sublime to the ridiculous. At the same time, compensation and property disputes came in at such a rate that a special Fire Court was established to ensure a speedy resolution. Some of the destroyed buildings seemed to have multiple owners who wanted to claim compensation or, conversely for those structures that had been built illegally, no owners at all. The Fire Court was charged with unpicking the tangled strands of claim and counterclaim and ensuring that each case was wrapped up quickly.

The responsibility for rebuilding the City of London fell to the six commissioners for rebuilding, one of whom was Sir Christopher Wren. Although many proposals for a new layout were put forward, in the end those public buildings that had been razed were rebuilt on their original sites, and though no radical restructuring took place, the look of the city was completely transformed. Gone were the tottering tenements that blocked out the sun, with the narrow alleyways replaced by wider, safer streets and access to the Thames improved. Where once timber slums had crowded along the wharves, now the waterways were clear, the highly combustible goods stored there kept safely away from residences. Under strict new laws, all buildings had to be made of stone or brick, the better to resist fire. The churches that had burned and Saint Paul's Cathedral were rebuilt according to Wren's designs and Charles II ordered a memorial monument to be constructed to commemorate the fire, also designed by Wren.

For those who moved into new buildings, conditions were greatly improved, yet the wait for accommodation was long, and slums were far from a thing of the past for the people of London.

The Great Plague is thought to have largely subsided in London when the fire struck

PSA FLIGHT 182

1978 CALIFORNIA

In the skies above San Diego, on the morning of 25th September 1978, Pacific Southwest Airlines Flight 182 collided with a private light aircraft. Both aircraft cashed into a residential neighbourhood. 144 people lost their lives in the accident: all crew and passengers of the PSA flight, the two Cessna pilots and seven people on the ground.

THE SAN FRANCISCO EARTHQUAKE

San Francisco ferociously burned in the days following the devastating earthquake of 1906. But for a team of scientists, it was true education

The front-page headline of the special *Call-Chronicle-Examiner* perfectly summed up the events that took place in San Francisco on 18th April 1906. Printed the morning after, the combined publication of the city's three newspapers splashed: "Earthquake and fire: San Francisco in ruins." What was written beneath laid bare the devastating, immediate effects. "Not a business house stands," it said. "Theatres are crumbled into heaps. Factories and commission houses lie smouldering on their former sites. All of the newspaper plants have been rendered useless."

What the journalists did not immediately know as they hunched over their typewriters in their bid to make sense of that dark day was that some 3,000 people would be killed and 225,000 left homeless over the coming days. Yet the earthquake was hugely significant for another important reason. Scientists, for the very first time, began building a wealth of knowledge about quakes. "It

basically gave birth to modern seismology," said Dr Jennifer Strauss, who works at the Berkeley Seismological Laboratory in California.

In the weeks and months following the earthquake, scientists diligently sought to map, report, describe and analyse its cause and effects in the tiniest of detail, producing a 17-page preliminary report within five weeks and a larger, more in-depth follow up within two years. More information was gathered about the San Francisco earthquake than any other in history and the information gleaned from it led to discoveries that have informed generations of seismologists ever since.

Yet when residents were jolted from their slumber at 5.12am on 18th April, none of that was of primary concern. For them, as the earthquake struck without warning and lasted for 48 seconds, punctuated by violent shocks, safety was foremost in their mind. Those already bright and alert – including a Mr Barrett who was believed to be the news editor on the *San Francisco Examiner* and had finished work just moments earlier – would speak of the immediate consequences. They were terrifying.

"All of a sudden we had found ourselves staggering and reeling," he said, describing his walk home with a colleague. "It was as if the earth was slipping gently from under our feet." He recalled trying to get up but he was thrown back to the floor. "Big buildings were crumbling as one might crush a biscuit," he added. But that was just the start.

"People spoke of the earthquake going on and on and on," said Dr Strauss. "And as soon as they basically got on their feet and figured what was happening, all of the fires started." A ferocious blaze swept across San Francisco for three devastating days, sending temperatures soaring above 1,090 degrees Celsius. It destroyed vast swathes of the city's infrastructure and choked the air with smoke. "Much of the damage after the 1906 earthquake was due to fire," Dr Strauss continued. It was clear that after this event, the city of San Francisco would never be the same again.

The epicentre was offshore near San Francisco and the quake was felt from Eureka, close to the northern Californian border, all the way down to Salinas Valley. "It was most significant along the coastline and the areas of the peninsula where it was very, very violent," explained Dr Strauss of the quake that had ruptured the San Andreas fault to the north west and the south east. "Where the soil is loose sediment, you would have got massive shaking amplification. You'd be shaking like a bell."

The inmates of Alcatraz out across the Bay felt the earth move too, but while the prison building survived – with the damage confined to a sewer and the lighthouse – San Francisco was in chaos. Many people became trapped when the ground beneath the tenement district south of Market Street gave way and the buildings collapsed. Elsewhere, bricks and mortar fell from the sky, killing many

IN BRIEF

- **Death toll: 3,000+**
- **San Francisco, USA**
- **18th April 1906**

Understood to have been of a magnitude of between 7.7 and 7.9, the east coast quake of 1906 rocked California and Nevada but it notably affected populous San Francisco.

A building remains standing on Fourth Street as soldiers patrol

panicking residents in the streets below. As bodies began to pile up amid the twisted street car tracks, uprooted trees and tangles of electric wires, scores of people wandered the streets dazed and homeless in desperate need of shelter. Hungry and exhausted, the authorities and the residents made desperate rescue attempts but the fires, which had started in large pockets across the city, were out of control.

"A lot of people were still using candles at that time to light up the interiors of their homes so a lot of those would have fallen over," Dr Strauss said of the cause for some of the blazes. In the heart of Hayes Valley, a woman looking to make breakfast following the initial shocks did not know the chimney above the stove had been damaged. Her house burned down and destroyed a 30-block area.

"Wood stoves were being compromised either in the shock itself or in the aftershock. But the other thing that made the fires worse was a lack of water," said Dr Strauss. The water lines had broken from the rupture, which meant there was no way for people to put the fires out themselves."

The lack of an organised fire brigade didn't help and so, as the wind whipped up and fanned the flames, desperate measures were needed. To prevent the blaze from spreading, the city opted to create fire breaks, but the method was severe. "If there were a whole bunch of houses on fire, they would go to people's homes and tell them to leave because they were going to explode them," Dr Strauss said, the idea being to create a gap that would help stop the fire in its tracks.

"They set explosives, which is pretty scary when you think about it and also quite unfair," she continued. "People would have been sitting outside their house, wanting to go back in because the shaking was done and the authorities would be like, no, you can't. But as they were not exploded very well, it only increased the number of conflagrations to the point where a large portion of the city was burned. Highly flammable black gunpowder was used as dynamite and it only served to create a path for the fires. Burning debris also ignited ruptured gas lines, worsening the problem."

"People wandered the streets dazed and homeless in desperate need of shelter"

Luckily for future residents, much of this unfolding drama and devastation was captured by photographers who were documenting what they saw. It meant the earthquake became the first natural disaster to be pictured in such a way and the images went on to help scientists better study its effects. Just three days after the earthquake, Andrew Lawson, a professor of geology at the University of California, Berkley, got to work in heading a commission to investigate the earthquake and its effects. "The most significant thing to come out of the 1906 earthquake was the Lawson Report," said Dr Strauss.

Lawson had already earned much respect in this field. 11 years earlier, he had become the first person to identify and name the San Andreas Fault and so, following the earthquake and with the help of a core team of more than two dozen scientists, he was able to look more closely at this. The rupture was analysed and mapped to within an inch of its life, allowing a view of its full continuity. It was seen to stretch across California as a continuous geological structure of some 600 miles.

"They produced a massive compilation of reports on the damage, not only looking at where there were visible fault lines on the surface but looking at how buildings were damaged in different areas depending on how far away they were from the fault or what the buildings materials were," said Dr Strauss. "They produced some very detailed maps, as well as hand-drawn surveys and they had photographs of everything. This document became the benchmark for future investigations into the after-effects of earthquakes."

The resulting *The Report Of The State Earthquake Investigation Commission, Volume 1*, ran to 220 pages

A CITY UNDER LOCKDOWN

Shortly after the quake, Brigadier General Frederick Funston, acting commander of the Pacific Division, sent hundreds of troops on to the streets to help police and fire departments bring the population under control. It was similar to martial law, although such a declaration was never actually made. Instead, Mayor Eugene Schmitz, infamously gave the nod to the police and troops to kill anyone found stealing. That afternoon, three looters were said to have been shot.

Such actions were deemed necessary because the authorities feared looting and general disorderly behaviour. Before long, witnesses were telling of sentries "posted on every corner" and the comfort derived from hearing them proclaim, "12 o'clock and all is well". They would praise the troops for providing supplies of blankets, food, tents and for bringing portable toilets.

With no worries about their own family, given they were drawn from outside of the area, the troops were able to carry out their work with great effectiveness. There were guards outside the ruins and key buildings such as the post office and the vaults, and a more general sense of calm prevailed.

People were threatened with jail if they were caught starting fires to keep warm. Yet it was Funston who decided that dynamiting homes to create firebreaks was "the only way" of preventing the spread.

But there were some other consequences that didn't go down well. Colonel Charles Morris ordered "all liquor, except beer, shall be immediately seized and poured into the gutter of the ground so that it cannot be imbibed." Around $30,000 worth of liquor was destroyed out of fear it would not only spread the fires but be seized upon by gangs.

Soldiers outside the Hall of Justice in 1906

REBUILDING SAN FRANCISCO

Despite predictions that San Francisco would die, it rose from the ashes and, within weeks, it was starting to get back on its feet. Although it would take just short of a decade for the city to be completely rebuilt, a decision to simply erect buildings where the old one's stood rather than start to formulate ambitious remodelling plans certainly helped to speed up its recovery.

Street cars were trundling down Market Street within a month and tiny wooden cottages were created in the parks. "Once the city was rebuilt," said Dr Jennifer Strauss, "people put large pieces of wood under them and carried them to places of the city where they wanted to put down roots."

The banks were re-opened after six weeks and new railway tracks began to be laid. The clear-up job was long and hard, with the Marina District of today being filled with rubble.

The Victorian houses had also been destroyed but that was seen by many as a good thing: "I don't know if the people in 1906 – except for the homeowners – were particularly beat up about the fact that many of them were no longer with them," said Dr Strauss.

Yet there have been suggestions that it was perhaps rebuilt too quickly. The city held the Panama-Pacific International Exposition in 1915 and some believe buildings were rushed in preparation. Today, however, the Rockefeller Foundation's 100 Resilient Cities programme includes San Francisco and it is being helped to prepare residents and buildings for future quakes and fires.

(and if you want to view it for yourself, it is available to read for free on the Internet Archive site at: bit.ly/2aMD0Sp). The report showed a correlation between the intensity of the earthquake and the underlying geological conditions. Bedrock sites were less able to sustain strong shaking than sediment-filled valleys, it had been found, and reclaimed ground from San Francisco Bay was the worst hit of all the areas, with the coastal areas that were on sediment and soil becoming prone to the phenomenon of liquefaction.

It soon became apparent that the earthquake was linked to the continuous active fault and that ground motion would decrease further away from the fault. "But the one key thing that the Lawson report did was provide all the data and the basis for elastic rebound theory," said Dr Strauss, of an important explanation for how energy is spread during earthquakes. It had previously been thought that forces that led to an earthquake were concentrated close to the location of the quake. But when one of the research scientists, Harry Fielding Reid, studied the fault trace of 1906, he said the forces that caused the earthquake were actually very distant. He proposed that stress over many years distorted the earth to such an extent that it caused ground weaknesses – or faults – to fail.

"It's not like a 'the earth moves a foot in one fell swoop' kind of thing," said Dr Strauss. "It's more stretch, stretch, stretch, stretch and then snap, like a rubber band. So instead of these straight lines going across the fault, it starts getting curved. This formed the basis for our modern understanding

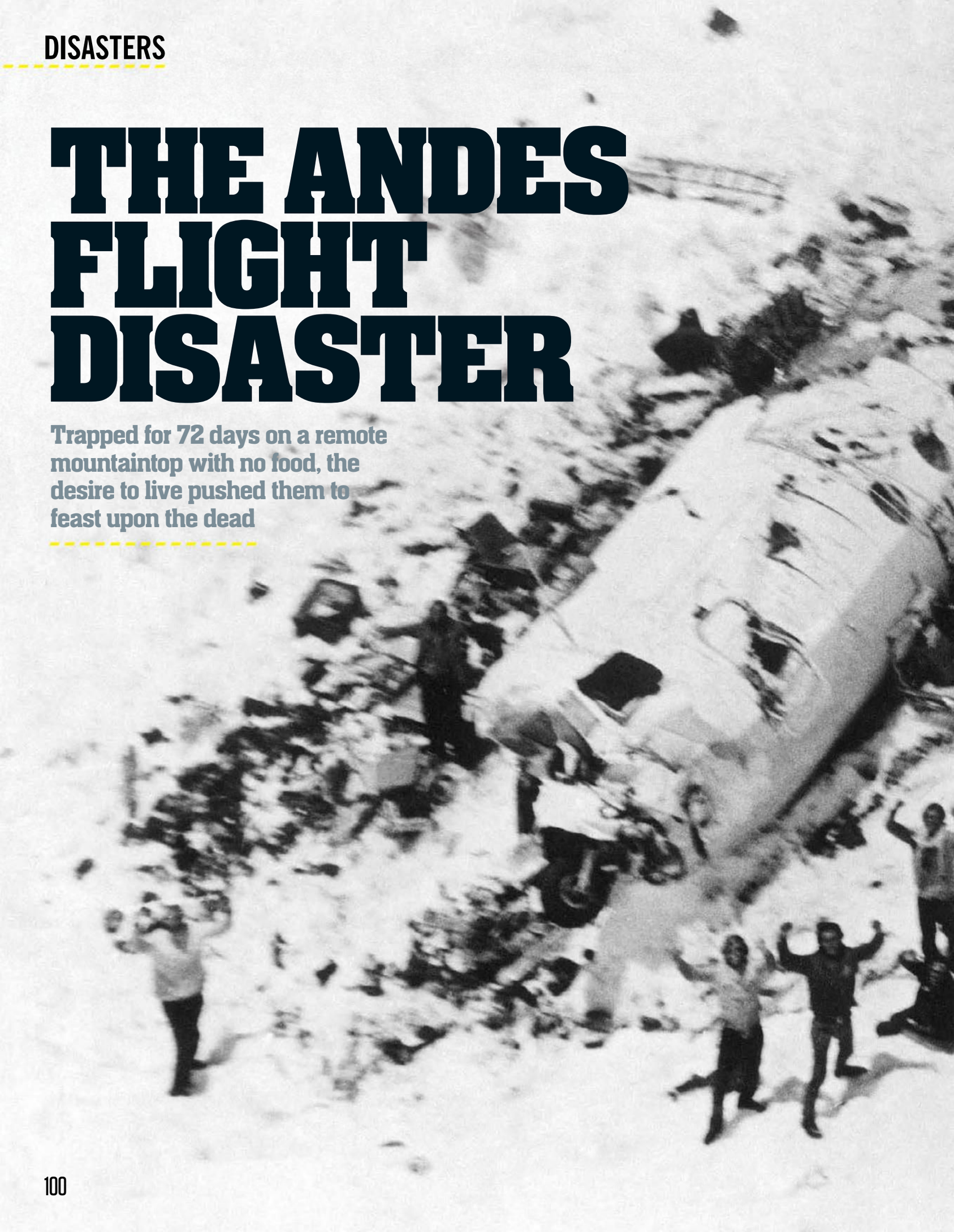
of earthquakes and how the crust movement gradually moves and distorts everything with the plate motion. This important discovery was made before plate tectonics. It's pretty amazing and it was a huge feat for seismology as a whole."

Lawson's report remains the authoritative work on a single earthquake and it has enabled San Francisco to be better prepared for any repeat. The Hayward Fault, which runs along the foot of the East Bay Hills, was to blame for the city's major earthquake in 1868 and studies have shown that it ruptures, on average, every 140 years. "The talk of the town is we are due a large earthquake," Dr Strauss said. "People have been working on resiliency strategies and ways to co-ordinate services. The city has a massive retro-fit programme for buildings to make them safer."

That's not to say the San Andreas fault has finished the job it began in 1906. "There is research suggesting that every once in a while there is an earthquake that can be re-correlated back to the 1906 quake. The aftershock sequence falls away over time but for these very large events, it takes a very long time to return to background seismicity."

THE ANDES FLIGHT DISASTER

Trapped for 72 days on a remote mountaintop with no food, the desire to live pushed them to feast upon the dead



THE ANDES DISASTER

IN BRIEF

- **Death toll: 29**
- **Andes mountains**
- **13th October 1972**

For 72 days, a team of rugby players from Uruguay were trapped in the Andes. That they survived a plane crash against the odds was nothing short of a miracle.

The mountain appeared out of the heavy cloud like a colossal beast from the nightmare imagination of HP Lovecraft, its dimensions so giant as to be nearly incomprehensible to the human mind. A holiday atmosphere turned to tense looks and softly muttered prayers. One passenger noticed the right wing of the plane was a mere ten feet from touching the mountainside. It wasn't standard procedure to get so close. Something was wrong.

Upon hitting another pocket of turbulence, Uruguayan Air Force Flight 571 shook violently. Passengers gripped their seats, waiting for the moment of impact. The right wing struck the mountainside first, tore completely free, cut off the tail, and sucked those at the very back out into the open air. The left wing broke away, leaving the plane's fuselage to resemble a gliding paper plane sans wings, ready to disintegrate. Instead, the fuselage struck the ground on its belly and shot down into a valley. As it came to a stop on a snow-covered slope, stunned survivors smelled fuel and expected the wreckage to explode at any minute. Seats had been dislodged from their bolted-down fixtures - with the occupants in them - toward the front of the plane. The result was a gory pile up of twisted metal and broken bodies. Twelve perished in the thunderous chaos of the crash, while others succumbed to their injuries the next day and in the weeks ahead. A few fortunate souls survived with little more than bumps and rattled nerves.

Flying across the Andes in small or medium-sized aircraft can be perilous at the best of times. The continent-stretching mountain range - the world's second largest - at the point in which Flight 571 traversed was a mere 100 miles wide. But its peaks in this region rise to 22,000 feet (with an average of 13,000 feet). One of them, Aconcagua, is only 6,000 feet short of Mount Everest. The Uruguayan Air Force-owned Fairchild FH-227D could reach a maximum flight ceiling of 22,000 feet, which meant it had to find a route via several viable mountain passes. Even the best pilots in the Argentine and Chilean militaries give the Andes a wide berth at certain periods of the day. Conditions there brew from the meeting of cold air with the warmer, volatile winds roaring down the valleys from off the Pacific Ocean. Turbulence can be frightening, but turbulence doesn't bring down planes. Storms producing heavy cloud cover and those wild gusts is the real threat.

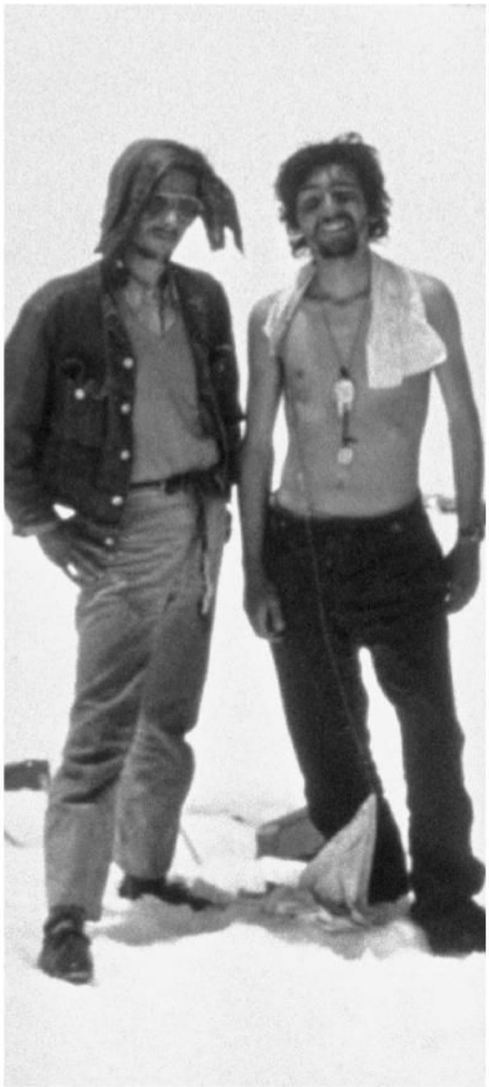
The plane had been rented out by the Old Christians rugby team from Stella Maris College, a Roman Catholic school set up in 1955. South America is well known for its love of football. But the Irish Provenance of Christian Brothers, invited over to start a school in Montevideo, couldn't do without their own pastime: rugby. Uruguay was a football-mad country, their national team having won the World Cup in 1930 and 1950. Rugby slowly began to take off and the Old Christians

team was born, with students and former students clinging to the sport as a social outlet and a way of continuing a sort of old boys' network after they'd graduated. But it wasn't rugby which taught the survivors of the plane crash the skills to succeed against all odds. A captain on the field does not necessarily make a leader in a disaster. While it gave them a particular sense of camaraderie – which helped to a point – their education and Catholicism played a pivotal role in the decision to eat the dead.

The story of Christ's 40 days and 40 nights in the wilderness, too, provided a mythological and spiritual anchor. Once they had settled the debate, it was physical revulsion survivors had to overcome. It's fine to talk about something in theory, but actually doing it? The line of transgression has been irrevocably crossed.

The Fairchild FH-227D was practically new with only 700 flying hours on the clock. Two pilots, Col. Julio Ferrádas and Lt. Dante Hector Laguara, were responsible for getting the team from their capital's Carrasco Airport to Santiago, Chile and back, so the lads could play a match against Old Grangorian. They set off at 6am on Thursday 12th October, following a path over Bueno Aires, across the pampas of Argentina and for the final bit of the journey – no more than 30 minutes – they had to cross the Andes.

Things had not started well. A flight lasting four hours had turned into a bit of a saga. Due to weather conditions on the final stretch, the pilots set down in the city of Mendoza, on the Argentine side of the range. They'd wanted five whole days in Chile to play their game, go out socialising, to chat up girls. Not everybody on the flight was an Old Christian. Many were family members coming



Survivors placed chairs outside the fuselage and sat in the sunshine

A grimace or a laugh? Survivors sit in the snow outside the fuselage

"Equipped with the latest radio equipment and tracking technology, the Fairchild shouldn't have encountered any problems"

along for the ride, or pupils from another school – a Jesuit college – to make up the numbers. One passenger wanted a cheap flight – tickets were $40 – to see her daughter get hitched to a political exile.

It was ultimately human error which led to the crash. Flying across the Andes in the afternoon is the riskiest period. With a major delay already in effect, the pilots had to put up with the constant badgering and verbal insults by the Old Christians. Ferrádas and Laguara were being hectored into action. But they're weren't stupid. Weather reports had come in positing favourable conditions. While it would be rough-going, they decided they could fly over the turbulence. Deciding to head through the Pass of Planchon – the least risky flight path – they set off at 2.18pm, setting a course for Chilecito and Malargüe and climbing to 18,000 feet, following an air corridor known as G17. Equipped with the latest radio equipment and tracking technology, the Fairchild should not have encountered any problems.

Weather factors and the pilots' decision-making combined to cause the crash. Ferrádas and Laguara began the plane's descent while still in the middle of the Andes. A tail wind had suddenly become a head wind, and it reduced the speed of the aircraft from 210 knots to 180 knots. At 3.21pm, Laguara radioed into Santiago and informed them they were over the pass and would reach Curicó (in Chile) about nine minutes later. Turning at a right angle, the plane was authorised by Santiago to bring the plane down to 10,000 feet. Sound enough, but they were taking the word of Laguara, who could only estimate their position due to the bank of cloud. He believed they had passed over and were on the final approach into Santiago's Pudahuel Airport. He'd radioed into Santiago that they were over Curicó and descending had commenced. The Fairchild was nowhere near the small Chilean town. It was much further north. The fuselage finally came to rest at an elevation of 11,500 feet between two volcanos, the Sosneado and the Tinguiririca.

The survivors, dazed or in extreme pain, began to organise themselves and rationed what food they could scrape together. Roberto Canessa,

REACTIONS TO CANNIBALISM

They emerged out of the damp mist like an army running into battle. Canessa and Parrado couldn't quite believe what they were seeing. The world's press had slogged across rough terrain on foot for two hours with the express purpose of interviewing and photographing the two lads. Newspapers in South America declared it the 'Christmas Miracle'. But darker aspects of the 'miracle' were yet to be heard.

Cannessa and Parrado, upon making contact with the Chilean peasants immediately on the next morning, buried the rugby sock filled with human meat. When first questioned by the authorities, the guys claimed the plane had been well-stocked with grub and they'd taken to eating herbs dotted here and there.

Once survivors were ensconced in the St John of God hospital in San Fernando, the press badgered the 16 for exclusive interviews. Doctors had found the men undernourished and with various physical ailments, but they almost immediately understood – without words – the true means of survival. They said nothing.

Zerbino's two letters written on the mountain to a girlfriend were handed over to parents. Only then did it sink in. "One thing which will seem incredible to you – it seems unbelievable to me – is that today we started to cut up the dead in order to eat them." Parents worried about what the truth would mean, so they pleaded with their children, at least for the time being, to deny it. But they would not. "It's true," replied Daniel Fernandez, to his father.

The survivors were quite open about eating the dead and they were buoyed by the reaction of the Catholic church and then the press. "Morally I see no objection," announced Carlos Partelli, the archbishop of Montevideo.

Parents of those who had not made it were most distraught. How could they bury their loved ones if there was nothing left to bury but a few bones on a mountaintop? The image of sons, brothers, cousins, debased in so complete a fashion; for them the tragedy was also a transgressive indignity, their loved ones reduced to meat and consumed as food.

ROUTE TO RESCUE

Parrado and Canessa's trek pushed the boundaries of human strength

Daniel Storm and Gustavo Zerbino were in medical school. Storm was in such a bad state he was of no use whatsoever. Roberto and Gustavo rallied and began checking their fellow passengers, advising and assuring them about various conditions.

Outside, several of them attempted to take in what had occurred. When they tried to walk on the snow, they fell in waist-deep. The views, in a less life-threatening situation, would have been marvellous. They were trapped, and yet for the moment they were equally full of hope. When the plane hadn't landed as scheduled the search parties would be out, their last known position used as a starting point for the exploration. They weren't to know the pilot's co-ordinates were off by 55 miles.

In the days that followed more survivors perished. Fernando Parrado hadn't moved since 'landing' and some among them believed he was in a coma and would pass away silently. Parrado had travelled with his Old Christians squad and brought along his mother and sister. The mother, Eugenia, died during the mayhem of the descent into the valley. One morning, miraculously, Parrado awoke from his slumber, face bruised and head throbbing. He soon learned his mother was gone, but immediately set about comforting Susana, the sister, who was mortally wounded and fading fast. When she passed away on the 8th day, something else awoke in young Parrado: the desire to not only live, but to take control of his own destiny. He must defy their situation and nature's insouciance to his plight. He was the first to discuss walking out of the mountains on foot and fetching help; to sit idly was to make matters worse. Survivors scoffed, but Parrado's iron resolve made them reconsider.

"They were trapped, and yet for the moment they were equally full of hope"

It was on the ninth day, rations having been depleted by false news of imminent rescue, that Parrado told a friend bluntly he wished to leave – to literally walk from the wreckage and out of the mountains into Chile – and save himself and others from certain death. "I'll cut meat from one of the pilots. After all, they got us into this mess," Parrado told Carlitos Páez. His friend thought the idea mad, but he mentioned it later on, when Parrado's plan became widely known. Roberto Canessa, who would eventually join Parrado in his quest, was having none of it. "We'd never make it. Look how

FACTS

13,000ft the elevation of the crash site

45 people on the flight

TWELVE fatalities in the crash

EIGHT fatalities in the avalanche

10 day trek down the mountains

2 MONTH wait for rescue from the peak

Sixteen survivors rescued

THE TREACHEROUS TREK

DAY 1 Canessa, Parrado and Vizintín begin their journey up and over the mountain. They climb due west up incredibly steep slopes.

DAY 2 Canessa believes he sees the outline of a road on the opposite side of the valley. He suggests heading there.

DAY 3 Parrado climbs to the summit, Canessa and Vizintín stay below. Parrado sees two peaks due west without snow.

DAY 4 Vizintín returns to the fuselage. Canessa and Parrado head off alone to down the mountain with more supplies.

DAY 5 "You can make it tough, God, but don't make it impossible," becomes Canessa's motto. They struggle on.

DAY 6 Canessa and Parrado reach the bottom of the mountain and enter a valley with two exits. Canessa begins to struggle.

DAY 7 Parrado takes to goading an increasingly weak Canessa. They reach the end of the valley.

DAY 8 Canessa and Parrado enter the green hills of Chile, but the going is still difficult and fraught with obstacles.

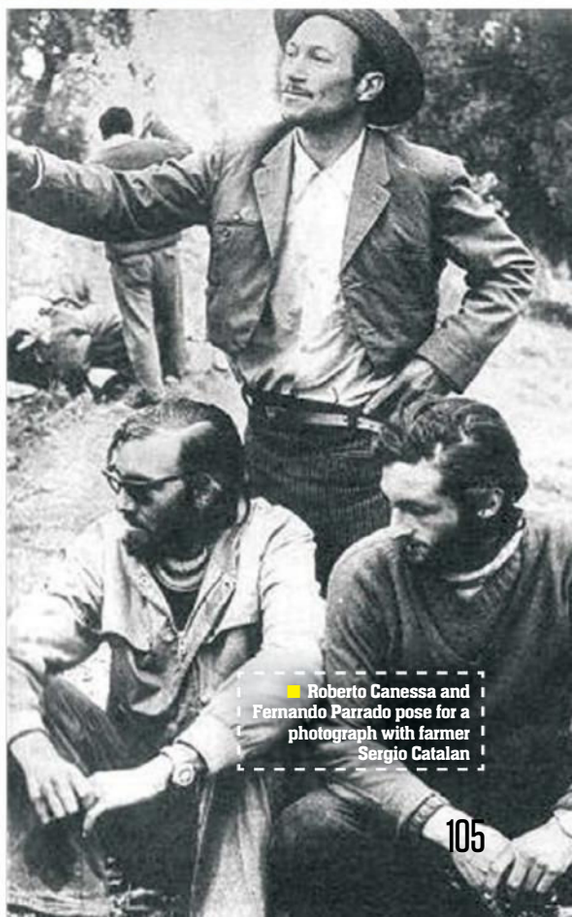
DAY 9 Canessa is suffering from diarrhoea and is now extremely weak. Later that day, they spot three men on horses.

DAY 10 They awake and make contact with a Chilean peasant in a field across the river Azufre. The ordeal is over.

weak we have become". It is then Páez said, "Do you know what Parrado said to me? He said if we weren't rescued, he'd eat one of the pilots to get out of here". The reaction, however, was not one of outright condemnation at such a grotesque, taboo-shattering solution. "I don't know... It might be the only way to survive," replied Adolpho Strauch. The seed had been firmly planted.

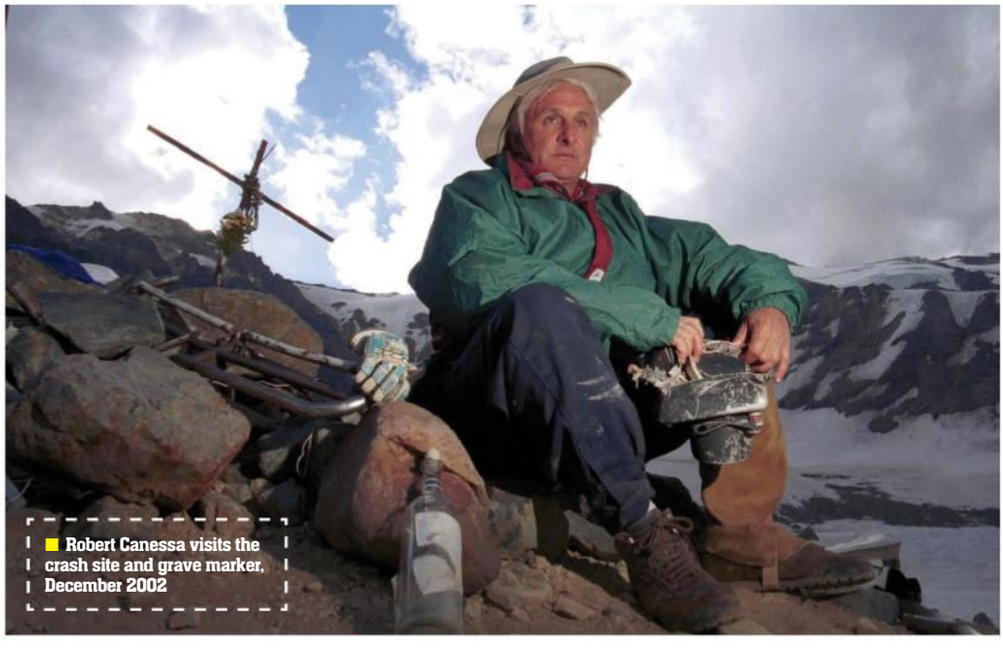
The Hollywood movie *Alive* had to be delicate with the cannibalistic content of the story. As a piece of mainstream entertainment, it fit right into America's love for a tale about triumph over adversity. But to show the survivors chowing down on dead folk would be too much for the audience; this wasn't a zombie movie delighting in gore effects and extreme violence. The film did little more than show Canessa (played by Josh Hamilton) cutting off frozen flesh from the buttocks of a body lying flat in the snow with a piece of broken glass. The reality was of course, far, far bloodier.

Although educated in a Christian environment and with the prospect of cannibalism in front of them, not everybody hunkered down in the fuselage was a holy roller. Some were devout, some saw their Catholicism as a comfort blanket, a few were non-believers. The survivors spoke for hours and hours about what the crash meant. Not how and why happened but in spiritual terms. Why did God want them to suffer so extremely? What did it mean? To provide a scientific perspective - Canessa was also among the most religious of the survivors - he offered his medical expertise (as far as a medical student still learning his trade could). He told them all straight about how every time they moved they were expending energy they could ill afford to because there was nothing with which to replace it. The meat would provide sustenance and



Roberto Canessa and Fernando Parrado pose for a photograph with farmer Sergio Catalan

The survivors arrive back in Montevideo, having been convinced to fly



Robert Canessa visits the crash site and grave marker, December 2002

energy. It would be morally wrong not to partake, no matter how horrid the prospect. "The souls have left the body and are in heaven with God. All that is left here is the carcasses, which are no more human beings than the dead flesh of the cattle we eat at home." The imperative was to survive and they considered cannibalism a virtuous act.

A meeting was called among the 27 survivors. They debated what to do. The Old Christians still sought to make decisions like they would discuss a game plan on the field. Marcelo Perez was their captain but he slowly crumbled in the situation, his authority diminished. New leaders would emerge as well as a curious sort of class system and cliques. Some refused point blank to eat their friends and family, or even strangers. It didn't matter one way or the other, the answer was 'No'. Liliana Methol (who later died in the avalanche) put forth the view that a social taboo was not a law of God. She would not partake in cannibalism, but would not object anybody doing so. When somebody put forth the idea this was a test from God, it was rebuked. If this was a test by God, what had they done to deserve it? They were middle-class lads from good homes. What kind of God would force those who had done no wrong to eat the bodies of their friends and relatives? Marcelo Perez was among those who thought cannibalism was a step too far too soon. He still held hope they would be rescued any day now, so eating the dead was a line not to be crossed. Perez would also perish in the avalanche which struck on 29th October, killing eight, but providing more food sources for the remaining group.

The ultimate decision - for all the philosophical and theological arguments the lads could muster - came down to a core existential instinct: an intense desire to live; to rebel against their terrible circumstances and return to their families. In order to achieve such a goal, they had to take extreme measures. Haunted by the prospect of transgressing social rules, their religious beliefs - whether strong or wavering - provided a bedrock.

THE MOUNTAIN IS ALWAYS THERE

Over 44 years on, the Miracle of the Andes has continued to garner press attention and interest from the public. Movies, documentaries and a range of books and memoirs have been written, going over the same story with fresh takes and details. There is even a museum dedicated to the disaster in Montevideo, Uruguay.

Two years after the incident itself, Piers Paul Read's *Alive* (1974) was published to major critical and commercial success. Based on hours and hours of interviews with survivors, the horrors still clear in their minds, it has become one of the great non-fiction books of modern times. In 1993 came the Hollywood movie adaptation by the same name. The film told the tale with most of the gory details left out.

To mark the 40th anniversary, survivors – those still living – decided to commemorate the occasion by playing the rugby game that had been cancelled between the Old Christians and Old Grangorian team from Santiago, Chile. On 13th October 2012, they took to a field in the foothills of the Andes. Parachutists dropped from the sky, their chutes designed in the colours of the Uruguayan and Chilean flags. Before the game commenced, they were presented with a commemorative display featuring the photos of those who had perished in either the plane crash or during the days after. Those they had lost were there in spirit. The men wept.

In a very recent online interview with Pedro Algorta in March 2016 for *Vice magazine*, he summed up his feelings about the incident. "Well, I have to say it never comes back to me. It never comes back to me unless I'm speaking about it, like now, but it's not something that comes back to me. As I said before, it's not bringing up nightmares. We have been able to live with it and are at peace with the mountain."

Canessa went out into the snow, cut off pieces of meat from the buttocks of a body lying face down in the ice and snow, and stuffed it into his mouth quickly. As he forced the frozen meat down into his gullet, holding back the intense urge to vomit, Canessa had crossed the line. He was the first to do so and the bravery of his decision seemed to galvanise the others. He cut off more pieces and left them on the rooftop of the fuselage. Sheepishly, hesitant, fellow survivors one by one took their pieces.

If Canessa saw his - and their - survival as a virtue, neither could they be fussy about it. They were, however, respectful to a point. They did not eat people whose living relative or friend might be offended. When Liliana Methol died, Javier Methol (the husband) was mentally tortured by the idea his wife's remains would be used as food. But the group told him her body would be left alone. It was during the big meeting that Gustavo Zerbino made a comic announcement: that if he died they were welcome to tuck in, and if they didn't he'd come back as a ghost and "kick them in the ass."

Susana and Eugenia Parrado were left alone out of respect for Parrado, but as he set off on his great adventure with Canessa and Vizintín, he told those left behind that if the worst came to the worst they must do what they had to do to keep on living. The sacrifice Parrado was willing to make - to have the remains of his mother and sister in the bellies of survivors - didn't just move them to tears, it wowed them on a spiritual level.

In the days that followed, the weather began to change. But as the snow melted, bodies once kept refrigerated by the ice and snow became exposed and in the hot sun, they began to putrefy. The oncoming of summer also brought the first signs of non-human life such as condors, bees and one day a butterfly fluttered into the fuselage. A new challenge was also about to present itself.

As the meat on the thighs, buttocks, legs and torsos became scarce, survivors had to turn to other parts which had previously been left alone. Hands and feet were munched on. They cracked open bones to cut out the marrow. Tongues and testicles were tried but deemed too difficult to swallow. Blood clots found around the hearts. Kidneys and livers. The contents of small intestines found in the snow were squeezed out and eaten. It became a search for new taste sensations as much as the desperate need to live. Later those rescued from the mountain would describe the taste of putrefied flesh as tasting like cheese. Even brains were eaten. Canessa cracked open a skull, pulled away the scalp and cut out the grey pieces. He told others that there was little nutritional value but the brain stored glucose and they desperately needed it. Their bodies hungered for food but it also demanded other minerals to keep them going. Stews and broths were made with a mixture of body parts.

Re-creating the nightmare for a museum exhibit, December 2002

After two months in the mountains, it was finally decided a team consisting of three should head out and search for help. An earlier mission to retrieve the radio battery from the tail of the plane had failed. They knew that Chile was to the west of the crash and this small snippet of information became sacrosanct knowledge. It could not be questioned. They therefore had to climb the mountain in front of them and see what the lay of the land was on the other side. Nothing was for certain. Parrado imagined verdant valleys, Canessa was less optimistic. Joining them was a reluctant Antonio Vizintín. They were given choice cuts of meat and body parts and permission to work less around the camp.

The walk to freedom has gone down in 20th century history as a most remarkable feat, but it was not without some cruel ironies. If the trio had followed the route down the mountain toward the fuselage, they would have come to a valley. Three days of trekking would have brought them away to a mountain road. Five miles to the east of the crash site was an abandoned summer hotel. Instead, the trio took the hardest, most dangerous route imaginable. That Canessa and Parrado scaled a 13,000 foot peak with no climbing gear - using their bare frozen hands and pieces of metal to smash or dig pockets into the ice and snow - is remarkable. That they then succeeded in their mission against everything nature could throw at them and then some is a triumph of human endurance and desire. They kept going because they refused to bow down to the futility of the situation and sit back to die.

IN BRIEF

- **Death toll: 15,000+**
- **Tōhoku, Japan**
- **11th March 2011**

The events in Tōhoku would represent the most catastrophic disaster suffered by the nation of Japan since the dual atomic bombings of Hiroshima and Nagasaki.

TŌHOKU EARTHQUAKE & FUKUSHIMA MELTDOWN

In 2011, a trio of domino-like disasters sent the capital of Japan into meltdown and nearly brought a world superpower tumbling down

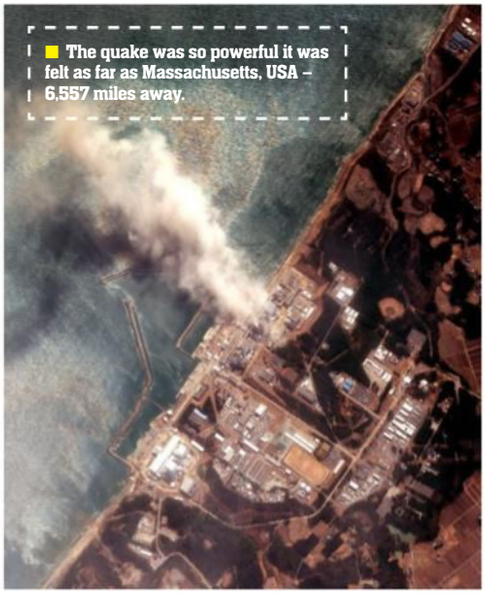
Before that fateful day in 2011, the town of Fukushima was a quiet and restful region, famed for its lush green mountains, ripe summer fruits and tranquil hot springs. The enviable beauty of this peaceful region in north-east Japan was broken only by a true contrast to its natural panoramas - the Fukushima Daiichi Nuclear Polar Plant situated in its namesake capital city. Built in 1971, the 3.5-square-kilometre site was one of the nation's foremost sources of power and remained one of the 15 largest nuclear plants on the planet. An industrial beast - much like its sister site - it may have been, but it was a feat of engineering prowess that inspired national pride in many who worked there.

On Friday 11th March 2011, that calm, idyllic image of a sleepy region was torn asunder. In a matter of hours, an earthquake shook the nation to its core, conjuring a tsunami so powerful it swept homes, business and schools aside like tissue paper. Then that flooding reached the most critical point in the entire area - the power plant. Soon a region that had been shaken, flooded and pummelled into submission would be smothered in deathly fallout as the plant bled radiation. It was a terrible disaster of three, but it begs a very important question: was a country as experienced in earthquakes as Japan truly prepared for the fate that played out that day?

On the morning of 11th March 2011, the city of Fukushima (the namesake of the larger region it nestled within) moved about its business like any other day. Its 13 districts and population of almost 300,000 people worked, studied and laughed their way through the morning, the air loud with the horns of long-haul fishing boats and industrial ships as they sailed into port. It's a haven of life and activity, and one that has no idea the earth beneath it is about to move, as if cracked by unseen forces.

Deep beneath the city and the rest of the nation, the very mantle of the earth is beginning to subside. The country is positioned above a tectonic mosaic and the intersection of two colossal plates - the Continental Plate and the Pacific Ocean Plate - but the tension that holds these two plates in place, a force known as subduction, is beginning to shift. The Japan Trench, the geological fault line created between the two plates, is suddenly in turmoil. The Pacific Ocean Plate begins to slip further beneath the other, lifting the seabed itself by 80 kilometre over an area the size of Connecticut.

The effect of these titans shifting beneath islands of Japan creates a force so powerful that it's felt across the world. The energy churning below generates a geological echo resulting in an earthquake with a rating of 9.0 on the moment magnitude scale. It's the most powerful quake



The quake was so powerful it was felt as far as Massachusetts, USA – 6,557 miles away.

to strike Japan in history, and the fourth largest in history. Suddenly, Japan is rocked to its core as the earthquake spools itself into full force. It's 2.46pm.

For six minutes, normality is put to the sword. For six minutes, the very ground itself seems locked in a violent swaying and rolling motion. Windows shatter, buildings lurch so hard they seem like they might topple and the very fabric of existence seems to come undone. Terror hangs thick in the air, screams and cries can be heard and explosions boom in the distance as petrol tanks rupture. Entire cities shut down, transportation networks grind to a halt and electrical grids shut off across the region.

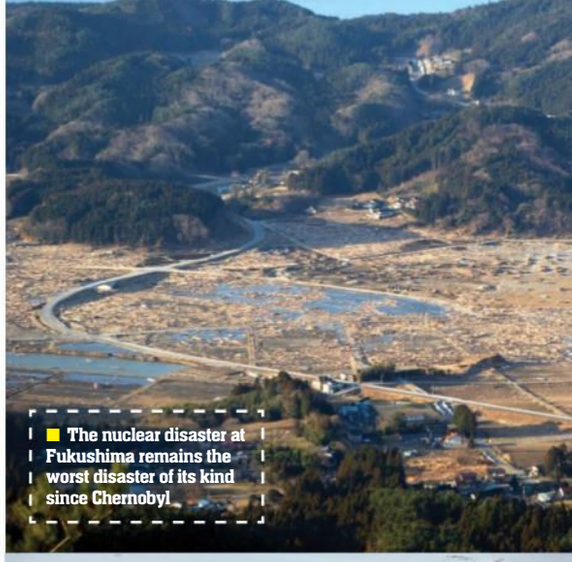
When the quake subsides, the citizens of Fukushima and the rest of Japan try to collect themselves. Cars are overturned; some are on fire; entire homes have been shaken to pieces; there's glass and dust everywhere. But the nation hasn't been levelled, and the level of distress and chaos varies from Hokkaido to Tokyo. Japan isn't gripped by an overwhelming sense of panic either – there's almost a bizarre, adrenaline-driven sense of excitement. A powerful earthquake has come and gone and life remains as it was, albeit with a great deal of mess.

Despite the severity of the earthquake, Japan was far from unprepared. Its Earthquake Early Warning (EEW) system was one of the most accurate – and the most costly – in the world with more than 10,000 sensors in place. Japan is a country that endures 1,500 earthquakes of varying seismic levels every year, and so the Japan Meteorological Agency (JMA) keeps tabs on any geological activity in case of tremors that could endanger lives. The EEW detected the shifting plates about one minute before the earthquake struck. The system sent out a national warning, which reached members of the public eight seconds before the shaking began. It was barely any time, but some members of the public had been informed, and tried to prepare.

Half an hour later, the first of many aftershocks begins. Registering at a powerful 7.4 and clocking in at 3.08pm, it only lasts for a few minutes. Another hits shortly after, although this one registers as less aggressive (these will taper off over time, but continue long after the disasters to come have subsided). As the people of Japan begin to gather themselves, those same forces that shook their homes and businesses were being boomed out into the ocean, creating a force of seismic energy so huge it could power the city of Los Angeles for a year.

The JMA's Earthquake Early Warning system registers a growing tsunami out at sea, one deemed so severe it's immediately classed as a 'major tsunami'. The JMA estimates the tsunami will collide with Japanese shores within half an hour, expecting it to tower as high as three metres. At 3.55pm, one hour after the first earthquake, a tsunami is reported colliding with Sendai Airport. It's the first of many as massive ripples of violent water and thrown towards northeastern Japan as high as 39 metres.

The walls of water smash into the airport, sweeping cars and planes aside as the water floods the surrounding areas. People flee on foot to no avail, while others attempt to escape on the roads leading away from the airport. The waters rage on, unabated.



The nuclear disaster at Fukushima remains the worst disaster of its kind since Chernobyl

International relief efforts were launched to help bring food and other aid to the Japanese citizens affected by the disasters

HOW PREPARATION PREVENTED A WORSE DISASTER

Japan is a nation somewhat accustomed to earthquakes that would terrify other countries. Over the course of 50-odd years it's crafted a series of national precautions and methods to ensure the nation reacts fast with the least number of casualties possible.

At the heart of that prevention lies the Earthquake Early Warning System, which monitors the tectonic movement of plates 24/7. When any seismic activity is registered, the data is proofed by the Japan Meteorological Society then broadcast across the nation with information showing the severity of a quake and its seismic origins.

When an earthquake is about to strike, all radio and TV channels immediately change over to an emergency channel that broadcasts information regarding safety steps and evacuation notice.

By law, buildings have been made earthquake proof with the help of deep, sturdy foundations and colossal shock absorbers that reduce the destructive effects of seismic energy. This is coupled with an ingenious method that enables the base of a building to move semi-independently to its superstructure, reducing the shaking caused by a quake.

In schools, children take part in monthly earthquake drills. In playgrounds they are drilled to move to an open area to avoid falling debris, and inside they are taught to use inflatable slides to escape safely. Fire departments regularly conduct drills in earthquake simulators to ensure young citizens understand just how dangerous a high-magnitude earthquake can be.

Japanese children take part in an earthquake drill

The fallout from the made some of the surrounding areas uninhabitable

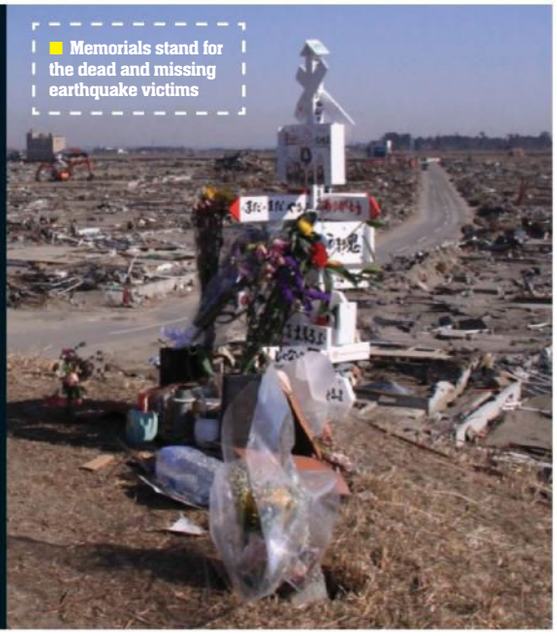
THE HUMAN COST OF FUKUSHIMA

It feels like an understatement to describe Fukushima as a mere disaster, what with the triple blow of an earthquake, tsunami and nuclear meltdown occurring all within a matter of days. Nevertheless, whatever word you can use to describe it, words fail to encapsulate the sheer loss of life wrought by the earthquake and the tidal waves that struck Japan as a direct result.

By the time Japan had begun its recovery in 2011, 15,894 people had lost their lives. According to Japan's Fire and Disaster Management Agency, about 2,000 died of post-disaster conditions with a further 2,500 still missing and presumed lost.

According to the National Police Agency, 95 per cent of the people who perished died of drowning, with 65 per cent of this figure aged 65 and over. Of all the casualties, 19 were foreign nationals from the United States, Canada, China, the Philippines, Pakistan, North Korea, South Korea and Taiwan.

Interestingly, as of 2016, there have been no recorded deaths in which radiation poisoning has been the main cause. Much of this prevention should be laid at the feet of the Japanese authorities and emergency services, whose evacuation plans saw more than half the population in Fukushima evacuated to a safe distance after the first hit of the earthquake.



Memorials stand for the dead and missing earthquake victims

"The walls of water smash into the airport, sweeping cars and planes aside"

Within minutes, thousands of people are drowned or swept to their deaths by the roaring violence of the rolling tsunami. A four-metre-high tsunami hits Iwate Prefecture, driving into the Wakabayashi Ward where 101 evacuation sites are positioned.

As with many earthquake/tsunami events, the waves that pummel into Japan create far more devastation than the earthquake and its aftershocks. Entire towns are completely obliterated, ripped to ribbons by water surges. Large parts of Kuji and the southern section of Ōfunato - including the port area - are nearly completely annihilated. The initial high death toll comes from the sheer heights of the tsunami waves - fleeing citizens think they can take refuge at higher ground, only to find the thunderous waves hunting them down regardless. The city of Rikuzentakata, where the tsunami rises to three storeys high, is completely destroyed and its population torn asunder.

The tsunamis don't strike the same area in intervals either - waves whip and thunder into areas across the north-eastern shores of Japan with a relentless vigour, with heights varying from four metres at the Shiogama section of Shiogama-Sendai port to a staggering 24 metres in the port of Ōfunato area. There is even news that the tsunami has reached heights of up to 40.5 metres in Miyako in Tōhoku's Iwate Prefecture. It's a monster of epic proportions and it's lashing Japan with all its might. Across the city, the waters have reached the worst place possible: the Fukushima Daiichi Nuclear Power Plant.

When the earthquake hit, the emergency protocols of the plant kicked into gear and the active reactors were shut down, their sustained fission reactions halted. Since the plant is no longer generating electricity and it powers itself as well as the rest of the region, it is no longer able to power the generators that keep the temperature of the reactors at a safe level. However, a series of emergency generators initiate to ensure everything remains safe and controlled.

However, although the plant may have been designed to withstand an earthquake, one of this particular magnitude was not accounted for. Workers operating on site witness the reactor walls of a number of the reactors begin to crack and crumble. Even before the tsunami hits, workers are already fleeing the scene. Confidence in the site's ability to maintain the unstable material it uses to run the plant is nowhere near as cast iron as it should be.

At about 3.40pm, 50 minutes after the first shock of the earthquake struck, a 13-15-metre-high tsunami wave collides with the plant and begins flooding it with sea water. With the plant's own seawall being 5.7 metres in height, the powerful wave passes over it with ease. The water rushes into the complex, slamming plant workers against walls and drowning them in the torrent of water. The current pours into every space and begins flooding the basement of the site. At 3.41pm, the water pouring in disables the emergency generators - suddenly a catastrophic situation has escalated to unimaginable proportions. Now the reactors are beginning to overheat.

A secondary backup system also fails to kick in due to the rising tide of water. Emergency services are automatically notified and scramble to transport

FACTS

6 minutes: the length of time the Tōhoku earthquake took to shake itself out

XI The classification the Tōhoku earthquake received on the Mercalli scale

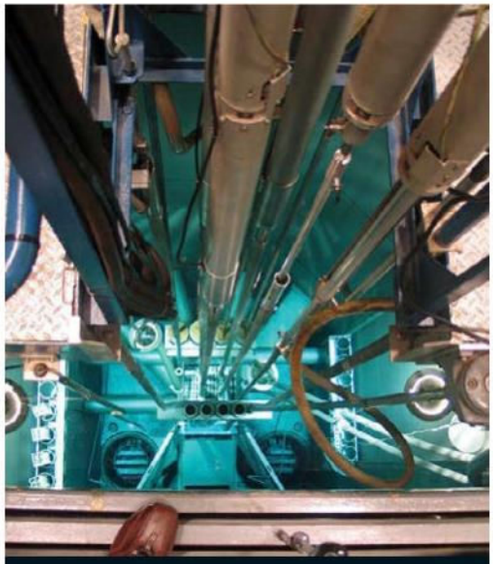
2.99g The peak acceleration of the Tōhoku earthquake

2,562 Number of people missing following the disaster

11,450 Number of aftershocks (as of March 2015)

37 Number of non-fatal injuries at the Fukushima meltdown

3 Number of electricity-producing reactors shut down immediately after the quake



HOW TO COOL A NUCLEAR REACTOR

To understand and appreciate the full extent of why we cool the core of a nuclear reactor, you first to have to take into account what happens if the radioactive material within is allowed to heat up unchecked. It's a fascinating process, but one that reminds you just how permanently dangerous a nuclear power plant can be if safety features fail as they did at the Fukushima Daiichi Nuclear Polar Plant.

Without a coolant being constantly pumped across and around its core, the materials within the reactor begin to heat up. At its simplest definition, this heat is an energy created when uranium atoms are split open. Uranium is a naturally unstable element and a nuclear reactor uses this instability to harness the energy released when these uranium-235 isotope fissions (another word for splits) occur.

In order to regulate and produce more nuclear fission, a reactor will need to reduce the temperature of the core, which in turn enables the continuous chain reaction of nuclear fission to produce more instances of fission, thus generating more energy. This is done by using a coolant or 'moderator', usually water or graphite. Water is one of the most common moderators, and its presence slows down the production of neutrons in the nuclei of uranium.

Plutonium accounts for about one third of the energy produced by a nuclear reactor, however this element is in actual fact a by product of the process and is actually considered waste. Nevertheless, plutonium naturally exhibits a high rate of spontaneous fission due to the rate at which it decays. This decaying material is highly volatile and it is this radiation that was detected leaking from one of the reactors during the initial stages of the disaster at the Fukushima power plant.

The core of a nuclear reactor, and the fission chain reactions within, are usually contained within a steel vessel that enables engineers to keep water flowing around a core in a liquid state, even at an operating temperature of 320 degrees Celsius. Hundreds of gallons of constantly temperature-regulated water is needed to keep a reactor from producing too much fission and thus overheating into a meltdown, hence the need for such large generators.

emergency generators to the site to halt the now un-cooled generators. However, the mud slides and flooded streets prevent the large portable generators from arriving at the sight until 9pm - five hours after the earthquake first hit. When they do arrive, no one is able to successfully connect them due to the intensely high water levels. Without sufficient cooling, the cores are heading for meltdown. A meltdown would mean the overflow of radiation and the contamination of the entire region. A nightmare has been realised.

As the levels of the cores of the reactors are being monitored remotely, it takes hours for the authorities to realise just how severe the situation could be. Put simply, if the cores were to become too hot, they would explode, scattering radiation in a wave of superheated air. The Japanese government has no alternative - the area, already flattened by the tsunami waves that continue to strike the mainland, must be evacuated and the plant cordoned off. A distance of two kilometres is ordered in case of a meltdown and explosion.

Seven hours later, this range is extended to ten kilometres as news of pressure levels rising inside the reactor cores has reached critical. Radioactive decay continues to increase the temperature of the cores - this in turn has generated a catastrophic amount of hydrogen gas that's nearing the very limit of its capacity. At 3.30am the following morning, reactor one can take no more and erupts - a font of radioactive material is blasted into the air as the roof of the reactor is blown off.

The Japanese army is now deployed onto the streets, helping ferry citizens through the flooded devastation as panic sets in. Not only have the people of Fukushima had to endure an earthquake and the most destructive tsunami to ever strike Japan, but the nuclear power station that's sat at the heart of their city is now poisoning it and their livelihoods with deadly radiation.

Yet all this time, the plant itself has not been abandoned - movements to cool the reactors continue as cold water is furiously pumped across each one in a futile attempt to halt the rising temperatures. On the morning of 13th April, the water cooling system for reactor three fails - less than 24 hours later, the reactor suffers a similar hydrogen explosion. A day later, reactor four goes

Some areas of Tokyo were devastated by both the earthquake and the tsunami

critical and blows apart just as authorities realise reactor two has been leaking high levels of radiation since the tsunami struck on 11th April.

According to estimates published by the Japanese national newspaper *Asahi Shimbun*, which based its article on the data collected by the Tokyo Electric Power Company (TEPCO), the amount of radioactive material released into the air by each of the ruptured reactors is close to 770,000 tera Bq when the meltdown occurs. For context, this is roughly 20 per cent of the radiation released during the Chernobyl accident. On 12th April 2011, the Japanese Nuclear and Industrial Safety Agency raises the rate of the accident from level five to the level seven – the same level given to the Chernobyl disaster.

Today, the region of Fukushima – and as a result, the rest of Japan – is still recovering from that catastrophic day, and it's a path that could take decades to navigate. Local tourism and trade has been impacted most of all – fisheries and agriculture torn to shreds by the connotation between the words 'Fukushima' and 'nuclear contamination'. It's an image that recalls perhaps the greatest nuclear disaster of our time, Chernobyl, a city still deemed too dangerous to enter. Tourists avoid the city and the region has seen its economy severely wounded as a result.

Fukushima and its surrounding areas still have radiation 'hot spots' that the government has sealed to ensure the attempts to shut down the plant safely doesn't risk any more Japanese lives. As a result, more than 80,000 citizens have been displaced with no sign of being able to return. Homes, businesses, schools and public services were abandoned in mere hours, and those still standing after the quake and the tsunami stand abandoned to rot.

In July 2013, the Tokyo Electric Power Company admitted that about 300 tons of radioactive water continued to leak from the plant every day into the Pacific Ocean. The cleanup of this radiation has proved a continuing issue for the Japanese government, its presence effectively destroying marine ecosystems in the surrounding areas. The Japanese government has estimated that the tsunami pulled close to 5 million tons of debris back into the ocean. About 70 per cent of this is believed to have sunk, leaving a good 1.5 million tons floating in the Pacific Ocean.

The radioactive materials that leaked profusely following the meltdowns at the plant were just contained to Fukushima and the surrounding Japanese regions. The waters that washed into the plant, the ones that caused the meltdowns in the first place, became enriched with unstable radiation and were swept out back into the ocean. In the months and years that followed, low levels of radiation (now diluted by seawater) were detected as far away as California and the coast of Canada.

So what of the polar plant itself? After five years, is the nuclear site finally decommissioned on the slow road to recovery? In reality, the process of dismantling the site and removing the nuclear material is one that could take decades to complete. The Japanese government is still working the Fukushima Daiichi Polar Plant into a state of cold cooldown, whereby water is pushed past a reactor in order to take its heat somewhere else, and as of 2016, a total of four units have been decommissioned.

Unfortunately, despite national protests against their use, the Japanese government's faith in nuclear power has failed to waver in the aftermath of the earthquake and the monolithic tsunami that followed. Much like the aftermath of the Kobe earthquake in 1995, Japan seems eager to fortify its nuclear future without truly understanding why the Fukushima Nuclear Daiichi Polar Plant destabilised as rapidly and as catastrophically as it did. Will its planned 60 billion yen new seawall be enough to protect the region and its remaining nuclear site? It's a question no one wants to the know the answer to, the memory of that nightmarish day now etched in the national consciousness for all time.

"A font of radioactive material is blasted into the air as the roof of the reactor is blown off"

THE LEGACY OF FUKUSHIMA

It's been over five years since the earthquake, tsunami and nuclear power plant disaster flattened Fukushima and the surrounding towns and turned them into Chernobyl-esque ghost towns, and in 2016 this once thriving Japanese region is now an eerily quiet shadow of its former self. Half a decade on, Fukushima is still haunted by Japan's worst nuclear disaster in history.

Much like its namesake capital city, a large proportion of the Fukushima region is now a cordoned-off wasteland full of abandoned homes, businesses and schools. Weeds are bursting through the concrete roads while thick layers of rust can be seen on the bonnets of abandoned cars, evidence of a population that was forced to up and leave in a matter of hours. A huge, 20-kilometre-wide dead zone surrounds the power station, a colossal band of radioactive real estate certified as too dangerous to live in.

The small town of Futaba, the closest inhabited location to the Fukushima Daiichi Nuclear Power Plant, sits within this dead zone and remains one of the most contaminated areas. It's a locale so close to the leaking power station that it's likely to be turned into a radioactive dumping ground, deemed too dangerous to ever inhabit again

Another town in the evacuation zone, Naraha, had a population of 7,000 before the disaster and it too remains an eerie shadow of civilisation. It was recently deemed safe enough for habitation by the Japanese government, a symbol of the nation's slow recovery, but confidence in such locations remains low and Japanese citizens are hardly flocking back in their droves. Fukushima has done more than just impact the economy of a single region, it's rocked the confidence of the nation in is reliance on nuclear power, permanently forcing the issue of nuclear reliance firmly into the arena of Japanese politics.

IN BRIEF

- **Death toll: 11**
- **Gulf of Mexico**
- **20th April 2010**

The disaster at Deepwater Horizon remains one of history's most catastrophic oil rig calamities. When it sank into the water, it left the oil well uncapped, leading to the largest oil spill ever recorded in American waters.

■ Firefighting crews worked around the clock to contain the fires, but to no avail

DEEPWATER HORIZON

Once the site of the deepest oil well in the world, a freak accident aboard the Deepwater Horizon rig would turn it into an oceanic inferno

The skies over Macondo are black, thick with a smoke that spews from a dying structure on the warm Mexican waters. Fires rage, melting steel like wax and forcing emergency services to retreat as the flames begin to consume every corner of the rig. Lives have been lost and more are in danger with every passing moment. Below the waves, oil drawn from deep in the earth is pouring into the Gulf of Mexico, a font of crude fuel that pollutes the water much like the plumes of ashen smoke above. Soon girders begin to groan and the giant platform is slowly consumed by the oil-ridden depths. It is 20th April 2010, and this is Deepwater Horizon – the oil rig that wasn't ready to dig so deep for so long.

12 years prior, Deepwater Horizon was nothing more than a series of blueprints on the wall of an engineering firm in South Korea. Built by Hyundai Heavy Industries for oil drilling conglomerate R&B Falcon (which was later absorbed, along with Deepwater Horizon, into a larger firm called TransOcean), the giant rig was envisioned as an oil rig like no other – a behemoth capable of being moved from site to site that would use innovative drilling techniques to bore oil wells out in the deep water of the Gulf of Mexico. It was the first rig of its type to be created using technologies and innovations from a class of two while also being dynamically positioned.

Its construction, from the very first keel (the very bottom of a boat or submersible) laid on 21st March 2000 to its completion and delivery from South Korea on 23rd February 2001, formed one of the world's most advanced drilling platforms, and one that was capable of operating in waters up to 2,400 metres deep, to a maximum drill depth of 9,100 metres. On the eve of that fateful evening in May of 2010, Deepwater Horizon was one of approximately 200 deepwater drilling platforms capable of drilling in waters deeper than 1,500 metres.

For the best part of the decade, the titan that was Deepwater Horizon had drilled at multiple sites across the Gulf of Mexico, its team of scientists and engineers even discovering the colossal oil source known as the 'Tiber Field' a few months prior to its final mooring at Macondo. The Tiber Field well was the deepest oil well in the world at the time, and more than 1,500 metres further below the seabed than the rig was meant to be able to reach. The team operating Deepwater Horizon were making a statement – no potential oil resource was too deep or ferocious for it to tame.

But there was a rot growing at the heart of Deepwater Horizon, one that would see an incredible engineering marvel come undone through a series of errors and oversights. The first signs of warning came in March 2010, following a total of 16 incidents of fires or oil spills logged by the US Coast Guard. The blowout preventer, one of the most important safety features of a drilling platform, was damaged in an unrelated incident. Further checks showed the preventer was still fully operational, but not every crew member aboard was convinced that was the case.

When Deepwater Horizon arrived at its new site, known as the Macondo Prospect (and located about 66 kilometres off the southeast coast of Louisiana), it had over 100 staff working for TransOcean (the new owner of the rig), BP and other private contractors. By the eve of the disaster, 126 men and women were working aboard Deepwater Horizon. It was a hive of activity, cemented into the seabed and pummelling the earth for that precious crude oil.

But there was a tension in there that fateful night. Deepwater Horizon was weeks behind schedule, and a series of incidents had seriously damaged the faith of its operators. In March alone – a mere month before the explosion that ripped the platform apart – the staff of the rig had reported sudden releases of methane gas, drilling

mud falling into the undersea oil formation, a pipe breaking off and falling into the well shaft and three separate instances of the blowout preventer – a vital component of the drilling system that shut the system down before a drilling calamity would occur – leaking fluid, which meant it had been rendered potentially useless.

Morale was plummeting further than the drill that was piercing the earth beneath them and it was all the worse by a sense of apprehension that hung in the air like a smog. A confidential survey conducted among TransOcean employees revealed a tangible sense of fear to report a growing number of breaches in safety and operational protocols for fear of reprisal. In the months that followed the incident to come, investigations and interviews with the survivors revealed this fear ran deep.

TransOcean coveted the safety record of its prize drilling rig, with some employees even going as far as providing false data in reports in order to maintain the status quo. The firm would later cite these practices as a direct result of its clouded perception of the rig's safety record. Deepwater Horizon was still drilling, but there was an unshakeable sense that something was deeply, deeply wrong within its steel heart.

On 20th April 2010, Deepwater Horizon is 43 days behind schedule and preparing to receive a party of executives from TransOcean, who are to be take around the rig for a tour to reaffirm confidence in the project and the team operating it. One month prior, a BP executive had emailed the Minerals Management Service to report the aforementioned stuck pipe, stating the well would need to be plugged and the drill pulled back to avoid any sort of worst case scenario. At 5pm on 20th April, the team at Deepwater Horizon are now finally beginning the process of pulling the drill back, but initial tests have revealed a problem.

"The inferno erupts into the air like hellfire as the rig is engulfed by flames"

A number of rigs were moved into place to drill relief holes to relieve pressure on the Deepwater well

The measured psi levels are simply too high, and as more and more crewmen gather in the drill cabin to observe, more and more of them are becoming convinced that the drill has a leak. A leak could mean a font of mud that could blow the seals containing the oil flow. A leak could instead mean a build-up of highly flammable gas that could ignite and then immolate the whole platform. It is perhaps the worst news the crew could hear, but whatever the true cause, somebody has to work out what it is and cut it off, fast. Senior toolpusher Miles 'Randy' Ezell, who is in charge of the drilling operation, and day shift drill manager Wyman Wheeler struggle to contain their apprehension.

When the night shift crew arrives at 6pm, the night manager Jason Anderson orders a second pressure test, and the results suggest that the well is not leaking and that the first test was likely a freak blip that didn't represent the true pressure

THE ECOLOGICAL AFTERMATH

While the destruction of Deepwater Horizon was catastrophic for BP, TransOcean and the families of lost crew members, the biggest impact was felt by the ecological infrastructure of the Gulf of Mexico and beyond.

To counteract this, the US government used a number of practices, including the controversial use of chemical dispersants. These agents don't remove oil from water, but simply accelerate its dispersion, thinning it out to prevent it clogging beaches and natural habitats. However, while dispersants helped reduce the amount of oil that reached shorelines, it made the ingestion of oil easier for marine life. Shrimp and oyster populations were particularly badly affected, with fisherman in the Gulf of Mexico saying that these two species have never fully recovered.

Dolphin populations were also severely affected, with many dead dolphins washing up on Louisiana and Florida beaches. A report by the University of Illinois at Urbana-Champaign, which studied newborn and foetal dolphins, found the spill had contributed significantly to the decline in dolphin populations due to a high increase in infant mortality rates.

Pockets of oil or 'oil bubbles' still wash up on the beaches bordering the Gulf of Mexico to this day. Yet the worst reminder of the disaster lies deep beneath the waves.

Due to the sheer volume of oil released from the well before it was sealed months after the accident, and the use of those government-sanctioned chemical dispersants, a great deal of crude oil settled on the ocean floor. This descent was expedited exponentially by a process known as 'marine snow', in which marine life such as plankton consume the oil and secrete an equally thick waste substance. This highly viscous substance moulds algae and other detritus together, creating heavy clumps of oil-thick material that drop to the seabed like rocks.

Oil from the rig is still found washed up on beaches in the Gulf

within the drill site. A sigh of relief echoes through the drill cabin and the crew members from the day shift begin to file out as the clock chimes 7pm. Chris Pleasant, the subsea supervisor, wipes the sweat from his brow and heads below deck.

Down below, the group of VIPs are currently in the small conference centre while a presentation on platform safety is being conducted. Ezell quietly slips inside, before being called up and congratulated. The VIPs couldn't be happier - yet the drill is behind schedule, but not one day has been lost in the past seven years to injury. In an occupation as potentially dangerous as the one TransOcean and BP are working in, that's quite a statistic to behold and the air is filled with light-hearted chit chat and the sound of backs being heartily patted.

At 9.30pm, night manager Anderson is called back into the drill cabin. As the crews begin the countdown sequence to unlatch the drill and seal the well with cement, the pressure readings in the well go through the roof. A floor below, Pleasant and another crewman are flicking through the live footage of the CCTV cameras that are fitted around the rig. One of the men suddenly stops on a single feed that shows what looks like water spitting from the drill. Such an occurrence isn't out of the ordinary, but it is something else that is making the crewman's face turn white. Pleasant looks up from his paperwork and glances at the screen: there's mud gushing out of the drill and the well. Something terrible has happened...

On the rig's main open floor, the drill sealant has blown and mud is spraying 73 metres into the air, raining down on the platform and the crew like a thick, viscous rain. But the crew have to act fast, time is of the essence. If there's mud pouring out of the ruptured well, then that must mean there is combustible gas that could potentially ignite. Anderson races down and closes a series of emergency valves in an attempt to halt the flow of mud and gas, but the worst has happened: the well has had a total blowout and methane gas is pouring from the rupture. Anderson wakes a now sleeping Ezell and informs of what has befallen Deepwater Horizon's operation. It's the worst case scenario, and he leaps out of bed in an instant and rushes out of his quarters.

It's a cold spring night outside with growing high winds whipping across the Gulf of Mexico as the highly flammable gas begins to condense on the exterior of the rig: it will only take one naked spark and the entire platform will go up in a raging flame. The gas is spreading through the station, and as it reaches the engine room, the huge diesel engines that power the station stall and fail. At 9.49pm, power on the platform begins to blink out and the emergency generators kick in. Anderson is now working down on the drill with the rest of the drill crew trying to stop the flow of mud, gas and oil.

Three minutes later, the electric lights flicker. Two distinct and loud vibrations follow. Below the crew,

INVESTIGATING DEEPWATER HORIZON

In the wake of the disaster, with 11 people dead and a $560 million oil rig at the bottom of the Gulf of Mexico, investigations began into exactly what led to the explosion and who was really to blame for the catastrophe. Reports were conducted by multiple organisations, including the USCG national incident commander Admiral Thad Allen; the National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling; the Bureau of Ocean Energy Management; the National Academy of Engineering and more. BP also conducted its own internal investigation.

In November 2012, BP plead guilty to 11 felony counts relating to the deaths of the 11 workers and paid a $4 billion fine. On 4th September 2014, US District Judge Carl Barbier ruled BP was guilty of gross negligence and wilful misconduct under the Clean Water Act (CWA). He described BP's actions as "reckless" and went said TransOcean's and Halliburton's (the top offshore oil drilling services firm in North America) actions were "negligent". Barbier placed a majority of the blame for the spill at the feet of BP (67 per cent), with 30 per cent to TransOcean and three per cent to Halliburton.

FACTS

126 people
were working on Deepwater Horizon when it exploded

4 knots The top speed of Deepwater Horizon when in motion

112 metres
The length of the Deepwater Horizon oil rig

115 Number of people who survived the catastrophe

$1.4 billion
The fine levied against BP in 2015

$560 million
Total cost to build the Deepwater Horizon oil rig

SO WHO WAS REALLY TO BLAME FOR DEEPWATER HORIZON?

On 28th September 2010, six months after the explosion, BP released its in-depth report following an extensive internal investigation. The firm knew it was being scrutinised by and wanted to get itself ahead of the curve. The 193-page report deemed that the TransOcean employees operating the drill on 20th April had not correctly interpreted the data gathered from the two pressure tests that evening, thus expediting a scenario that ultimately led to the destruction of the well and the leak that followed.

While it did also state the crew should have redirected the flow of flammable gasses in the well sooner, it does admit that the firm did ignore the recommendations of Halliburton to include more centralisers (a device that keeps the casing or liner in the centre of the wellbore to help ensure efficient placement of a cement sheath) in order to prevent disasters such as the one that occurred at Deepwater Horizon. Once again, BP also reiterated that the safety record of the rig was not accurate, due to reports of falsified data and poor communication.

Two months later, the Oil Spill Commission determined that BP had not sacrificed safety in attempts to make money, but that some decisions had increased risks on the giant oil rig – including a "rush to completion" on that fateful evening that may have seen some procedures not given the complete attention they deserved. The Oil Spill Commission also determined six key areas where six different operations, equipments and tests were not completed or failed outright in the 32 hours leading up to the explosion that rocked Deepwater Horizon.

Firstly there was a small diameter hole obstructing dirt circulation, resulting in a dangerously high build up of pressure that led to the second and third issues. These two points relate to the cement used to seal the well, which was firstly not adequate for the role and secondly, the valves used to halt cement backflow were not sealed causing further issues. Next there were the two pressure tests that were not correctly interpreted and the rising levels of gas and oil that were not monitored enough to raise a warning. Finally, there was the issue of the failsafe on the wellhead failing to close, leading to the eventual rupture.

a bubble of methane gas is sent through the drill column by an abnormal and accelerated bout of pressure. It breaks through a series of seals, and one spark later, the methane ignites and the gas that is spread around the station bursts into superheated flames. All hell breaks loose.

The drill itself disintegrates as the drill column explodes. Platforms are vaporised and girders are blown apart. The inferno erupts into the air like hellfire as the rig is engulfed by flames and thick, noxious plumes of smoke. Jets of crude oil, now lit by the fires raging below, spew into the air like lava erupting from a hyperactive volcano.

As crewmen flee for the safety of the lifeboats connected to the edge of the rig, Pleasant rushes below, clawing through smoke, fire and destroyed corridors to reach the bridge. It's there that he will find the Emergency Disconnect System (EDS). There's a chance this failsafe system may still be operational – if so, it could shut off the well and stop the flow of ignited crude oil.

The system would seal the well at the seabed then disconnect the rig from the well to preserve it. It's the only thing that can stop the explosions. It's the only thing that can save the rig. When he reaches the control panel, the captain of the rig orders him to stop and not activate the EDS, but Pleasant has seen the raging fires that are consuming the rig from every floor and hits the switch anyway. But nothing happens. The EDS has failed and the flow of oil and gas continues unabated. The fact cannot be ignored any longer: the rig cannot be saved and must be abandoned before it ruptures completely and potentially sinks into the Gulf of Mexico.

Across the rig, Ezell is drifting in and out of consciousness. Caught off guard by the explosion, he's now pinned down by a piece of gnarled girder. With smoke filling the air and fires flickering all around, he drags his leg free and limps towards what feels like the tickle of fresh air on his face. A few moments pass and Ezell realises he's nowhere near a window – the air on his face he can feel is a flow of methane gas so moist it settles on his face like sweat. As he makes his way away from the gas current, he discovers the injured Wyman Wheeler.

Despite Wheeler's protests for Ezell to leave him and save himself, Ezell pulls him through corridors, strapping him to an emergency stretcher and dragging the injured crewman through the ruins of the rig. By this stage, most of the crew have fled the ship and the two main lifeboats have already dropped onto the water and departed to a safe distance. The font of burning oil was still roaring above as Ezell and Wheeler emerge onto the open deck, pockets of gas igniting and rocking the rig.

Ezell drags his crew mate's prone form to an emergency backup raft and the two descend into the water while any remaining crewmen well enough to save themselves leap from the platform into the cold waters below. Of the 126 crew aboard,

"With the well breached and no way of capping it, the crude oil poured out"

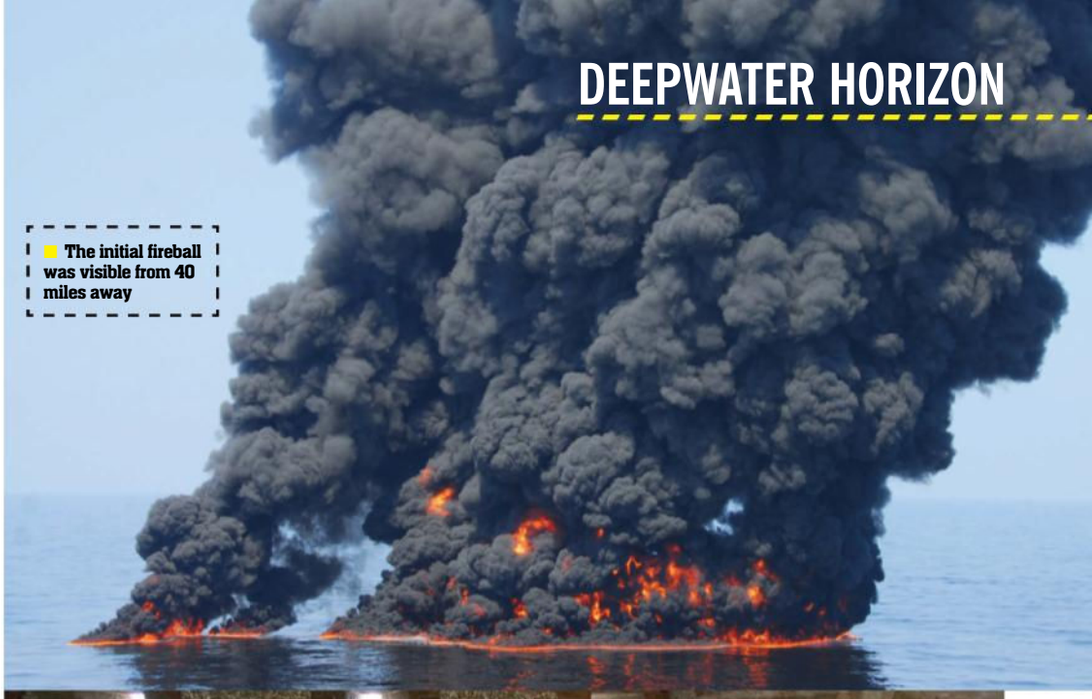
Oil choked the sea and its inhabitants, causing lasting damage to wildlife

115 were evacuated to safety – 94 were taken by lifeboat to the Tidewater-owned supply boat Damon Bankston, four were taken to another nearby vessel and 17 were carried by helicopter to trauma centres in Mobile, Alabama and Marrero, Louisiana.

Sadly, not every member of the Deepwater Horizon's crew survived the catastrophe. A total of 11 men were killed (nine workers from the platform floor and two engineers), including night manager and toolpusher Jason Anderson. Along with that heart-wrenching loss of life, the rig itself burned for 36 long hours before its structural integrity gave way and it collapsed into the Gulf, consumed by the hungry waves.

But the destruction of Deepwater Horizon and casualties among its crew were only the beginning of a far greater calamity. With the well breached and no way of capping it, the crude oil poured out of the seabed and into the surrounding waters. At the time, it was not immediately apparent just how bad the oil spill was. Coast Guard Petty Officer Ashley Butler was quoted by US news network CNN as saying that, "Oil was leaking from the rig at the rate of about 8,000 barrels (340,000 US gallons; 1.3 million litres) of crude per day."

The well was eventually sealed on 19th September 2010, following more than five months of continuous oil spillage into the Gulf of Mexico. The US government estimated the total discharge at 4.9 million barrels (210 million US gallons; 780 million litres), however reports were made right up to 2012 that the former drilling site of Deepwater Horizon was still leaking crude oil into the already heavily polluted waters.



The initial fireball was visible from 40 miles away

© Getty Images

LEARNING LESSONS

The disaster at Deepwater Horizon wasn't the first explosion and spill to occur at an oil rig platform (the fires that raged at Piper Alpha in 1988, which claimed 167 lives, being one of the worst in recorded history), but the incident in the Gulf of Mexico had a profound effect on the future of oil rig maintenance and deep sea oil drilling.

One of the biggest areas affected by the disaster is contamination and decontamination. Scientists around the world are now working on new methods for detecting and measuring toxic spills at a much faster rate. When Deepwater Horizon's untapped well pumped nearly 40,000 gallons of oil into the sea, the Coast Guard simply didn't comprehend the sheer scale of the spill. The hope is that the new testing methods will help reduce this blindspot significantly in the event of another disaster of this scale.

The use of dispersants is another area that's now evolving - the amount of chemicals used to thin the crude oil is said to have had an adverse affect on the marine life and environments of the Gulf of Mexico, so the US government is now looking to change how it uses such methods when faced with an escalating oil-related calamity.

"While the federal family was well versed in oil response and remediation, and we brought many resources to bear, the scale and complexity of Deepwater Horizon taxed our organizations in unprecedented ways," commented Jane Lubchenco, under secretary of commerce for oceans and atmosphere and NOAA administrator, in a statement in 2012. "We learned much during this extraordinary disaster and we hope the lessons learned will be implemented before and used during any future events."

SPANISH FLU

In 1918, Spanish flu killed more people than the number killed in the whole of World War I. How could one virus be so devastating?

IN BRIEF

- **Death toll: 20-40 million**
- **Worldwide**
- **1918-1919**

The Spanish flu pandemic hit a world already devastated by World War I and it proved to be the deadliest pandemic in modern history, infecting a third of the world's population.

A group of children play in one of London's parks. They are happy, and giggling, pleased that the council has closed their school for the week, giving them some unexpected free time. The streets they have walked through to get to this park are quieter than usual, and when they have passed adults, they have had scarves clutched to their mouths and noses, with some even wearing odd-looking masks, like the injured soldiers have been wearing since they returned from the war, to stop them, these children, from staring at the burns and the scars that they have come home with. The children start singing, and even though most of the adults near them are closeted in their houses and flats, their windows clamped shut, they can still hear the high-pitched words of the children come tumbling out:

I had a little bird
Its name was Enza
I opened the window
And in-flew-enza...

The song's words reflected the true horror behind the seemingly cheerful picture of children playing. A strain of influenza – known as Spanish Flu – had struck not only the local community, but the wider world, spreading rapidly, and hitting people indiscriminately. The young, the old, the sick and the healthy were being infected, and at least 10 per cent of everyone who sickened would die.

This was a world that has just been through the horrors of war. Many families would not see their fathers, brothers or husbands return from the battlefields, and others would see them come home as changed men, physically or mentally damaged by their experiences. And just as they returned, and those left behind hoped that their world would now go back to what it was, and that they will resume a peaceful, happy life, it became clear that there was a new, even more deadly, threat coming their way.

The war might even have been responsible for the Spanish flu pandemic that ended up killing so many people worldwide. Towards the end of the war, many soldiers, in

In Walter Reed Hospital, Washington DC, a nurse checks on patients on an open gallery

Farmers attempting to protect themselves from the Spanish flu in Canada, 1918

WAS SPANISH FLU ACTUALLY CHINESE?

In 2014, a new theory about the origins of Spanish flu was published that suggested it was not Spanish, but Chinese. New research placed the origins of the flu to the transportation of Chinese labourers – the Chinese Labour Corps – across Canada in 1917. These labourers, usually farm workers from remote parts of rural China, were shipped across the country in sealed train containers, part of the mobilisation of over 90,000 Chinese workers needed to work behind the front line on the Western Front. They spent six days in these train carriages, before continuing across to France, where they would be required to dig trenches, unload trains, lay tracks, build roads, and repair damaged tanks.

Previous research has suggested that Chinese people were less likely to die from the Spanish flu than other nationalities, perhaps because they had become immune following earlier exposure to the flu virus. There had been a flu-type illness in China in late 1917, known as the 'winter sickness' – not widely known about because of poor record keeping, and its relatively isolated location. Was this what had given the Chinese some immunity from the 1918 virus?

In one count of 25,000 Chinese labourers, some 3,000 ended their Canadian journey in medical quarantine. At the time, racial stereotypes meant that their illness was blamed on 'Chinese laziness', and so their symptoms were not taken seriously by Canadian doctors. By the time they arrived in northern France in early 1918, many were sick, and hundreds were soon reported to be dying. By the time the Spanish flu had become a worldwide phenomenon, though, the Chinese labourers appeared to have stopped becoming ill. While researchers may never be able to definitely prove the influence of the Chinese 'winter sickness' on the Spanish flu pandemic, it is certainly arousing interest, and has been described as a 'smoking gun'.

Members of the Chinese Labour Corps at work in France

their cramped, dirty, damp trenches in northern France, were becoming ill. Their tendency to become ill was put down to 'world-weariness' caused by their experiences of war – their immune systems were weakened, and they were malnourished, meaning their bodies weren't strong enough to fight off illness. They couldn't eat; they had sore throats and headaches. Their illnesses, which were known locally as *la grippe*, were infectious and spread among the soldiers. Within around three days of becoming ill, many soldiers would usually start to feel better – but not all, and not all would make it home.

Lieutenant Leo Mansfield Matthews, aged 35, had volunteered for active service, and had been on the front since September 1916. He died in hospital there on 25th June 1918, remembered by his fellow soldiers as a cheerful, bright, confident man who managed to cheer up his men "even in the most depressing moments."

During the summer of 1918, troops started to return to Britain, travelling by train. They brought with them the undetected virus that had made them ill, spreading it out across the cities, towns and villages. For their families, the happiness at their return might be soon replaced by horror and grief. There was no rapid recovery for many – both soldiers and civilians. The virus particularly hit the young, those aged between 20 and 30 who had previously been healthy. *The Times* reported that, "...persons who feel perfectly well, and are able to go about their business at 10 o'clock in the morning [are] prostrate at noon."

From the initial symptoms of a sore head and tiredness, they would develop a dry, hacking cough, a loss of appetite, stomach problems, and then, on the second day, excessive sweating. But then, the respiratory organs might start to become affected, and pneumonia would develop. This happened to Howard Brooks, a 19-year-old Londoner, who caught influenza and died of the pneumonia that then occurred. It also happened to 27-year-old naval instructor George Carter, who died of septic pneumonia following a bout of influenza. There were no antibiotics – no medicine that could make them feel better. Instead, people were given advice that amounted to seeking fresh air, cleanliness, a good diet and "constant disinfection".

"It was believed that the wet weather that most of Britain was subject to might stop the flu spreading there"

The newspapers, from January 1918 onwards, were reporting cases of people dying after influenza without making explicit any link between them – instead they were reported as isolated, unrelated cases. People were dying in the UK of influenza, but it was Spain – one of the earliest countries to see influenza hit, and which gave its name to this strain of the virus – that received more attention. However, even in May 1918, the Spanish ambassador in London had stated that, "The epidemic which has broken out in Spain is not of a serious character. The illness presents the symptoms of influenza with slight gastric disturbance."

But a week later, *The Times*, which had reported the ambassador's PR attempt as a true statement, was taking a different, more panicked, approach. By now, 700 people had died in ten days in Spain, and it was being reported that more than 100,000 people there had become infected within the two weeks since it had "appeared in Madrid". The papers now regretted their previous, jovial tone, and stated that the epidemic had "passed the joking stage". By this point, the flu had spread beyond Spain and reached Morocco. The king of Spain, Alfonso XIII, had been struck down with it, along with leading politicians. Where people worked or lived in close confines to each other, such as in schools, barracks and government buildings, 30 to 40 per cent of their populations were becoming infected. The Madrid tram system had to be reduced, and the telegraph service was disturbed, in both cases because there were not enough healthy employees available to work. Pressure was being put on the medical service and supplies, and they were failing.

Soon, it was being reported that the Spanish flu had spread to other countries in mainland Europe. One high-profile victim was the sultan of Turkey, whose death was reported in the *Daily Mirror* on 5th July 1918 – the paper regarding his death as rather trivial as "...he was a regarded as a nonentity in the hands of his advisers." Vienna and Budapest were suffering; parts of Germany and France were similarly affected. Many children in Berlin schools were reported as being ill and off school, and in the armament and munition works, absences were affecting production. In Frankfurt's factories, up to 50 per cent of workers were ill. The epidemic then reached Switzerland, with 7,000 cases being reported among soldiers of the Swiss army. Half the population of Motiers in the Vale de Travers were sick, and both telegraph and telephone services were affected by a lack of well staff.

Initially, when the epidemic was still seen as being restricted to Spain, it was noted that men were more likely to be infected than women, and that adults

DEATH OF A MOVIE STAR

Harold A Lockwood was one of the high-profile casualties of the Spanish flu pandemic. Born on 12th April 1887 in Brooklyn, but raised in Newark, New Jersey, the son of a horse breeder, he became an American silent film actor, and one of the most popular matinee idols of the 1910s.

Like many of his contemporaries, he had started his career in vaudeville, before moving over to the new movie industry in 1910, his obituary in the *Deseret News* stating that his, "...progress from that time was rapid." He appeared with May Allison in more than 20 movies, with the couple becoming a famous romantic pairing on screen. He also appeared opposite Mary Pickford in the movie *Tess Of The Storm Country*, and directed and produced films as well as acting; he also wrote a regular column for *Motion Picture* magazine.

During World War I, Harold worked on the home front, helping to sell Liberty Loans, a government bond. He also continued his movie work, and in 1918, started filming in Manhattan. However, he then became ill with Spanish flu, which then turned into pneumonia. On 19th October 1918, at the age of 31, Harold Lockwood died at the Hotel Woodward in New York, leaving behind a wife and ten-year-old son. He was buried three days later in the Woodlawn Cemetery in the Bronx, and his film had to be completed using a double.

His newspaper obituary noted that with the exception of his brief vaudeville career, he had, "...never appeared before the public except in motion pictures, and he was one of the best examples of the successful motion picture star." *Photoplay* magazine was similarly admiring of Lockwood, describing him as modest, a good worker, and a, "...clean, wholesome, worthy young American citizen in the very best sense of the term."

Many of his films continued to be shown in the picture houses; at the end of 1920, two years after his death, one movie, *Broadway Bill!* (1918) was being shown at the Pavilion Picture and Variety Theatre in Berwick, while *A Man Of Honor* (also 1918) was being shown in Portsmouth.

Temporary hospitals were needed including this auditorium

"Doctors were at a loss as to what to recommend; many urged them to avoid crowded places, or simply other people"

were at far more risk than children. Similarly, once it became a pandemic, and had spread to Switzerland, again it was stressed that men between the ages of 20 and 40 were most at risk. However, it was also said that those "on the slippery descent of middle age" were more likely to die once infected, because they tried to "fight" the symptoms too hard – instead of simply taking some quinine and going to bed with a hot water bottle.

The term 'Spanish Influenza' rapidly took hold in Britain. The British papers blamed the flu epidemic there on the Spanish weather – their spring was dry and windy – an "unpleasant and unhealthy season" that saw microbe-laden dust being spread by the high winds. Therefore, it was believed that the wet weather that most of Britain was subject to might stop the flu spreading there.

Many ordinary people had, due to the Great War, become interested in foreign affairs, and had read about the epidemic, discussing it with their friends and anticipating its arrival on British shores. Conspiracy theories abounded – were Germans carrying test tubes containing cultures from all known viruses and trying to infect other nations? Or was it the fault of Russia, the land of 'melodramatic mysteries'? The former conspiracy theory was debunked at the end of June when the German army was hit by the epidemic, with many soldiers being so ill that they were unable to fight. One of the side-effects of the virus appeared to be a deep depression, a lack of interest in life, and this was seen to be a symptom that might have been conjured up by those wanting to destroy morale. One victim was reported as saying, "Well, it cures ambition," and this summed up the lesser known dangers of becoming infected. Doctors were at a loss as to what to recommend to their patients; many urged them to avoid crowded places, or simply other people; other remedies included eating cinnamon, drinking wine, or even drinking Oxo's meat drink. Positives were sought; when it was reported that the Allies had had a good week on the front in France, it was speculated that this might have been helped by the flu, which was, "...known to be distributing its unwelcome favours with a lavish hand among the German divisions." In a rather British way, the

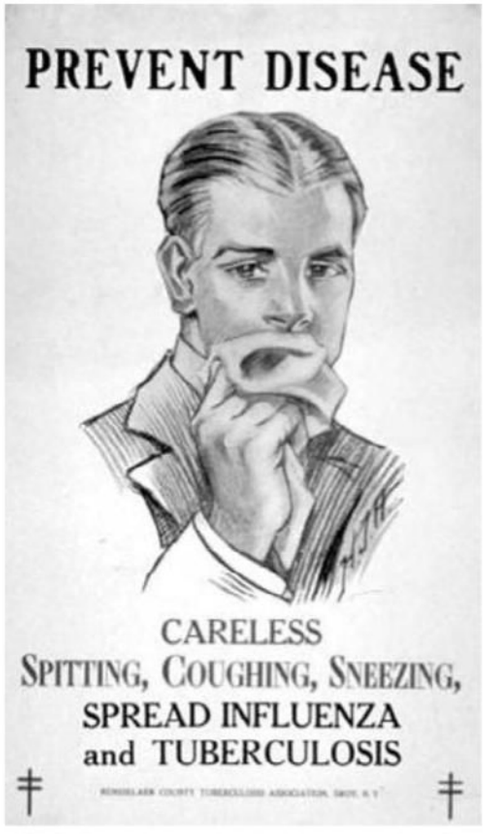
In army hospitals, patients' beds were reversed so that they would not breathe over each other

press noted that it was rather comical that the once-powerful Germans were being felled by something as mundane a virus.

It was, perhaps, inevitable that conspiracy theories would abound – the British press was subject to censorship during this period of war, and if the seriousness of the flu pandemic had been recognised in the press early on, this might have affected the morale of the nation. But Spain, for example, did not have press censorship, and published freer accounts of the illness in its pages. This had the effect of making people erroneously think it was an illness specific to Spain – Spanish flu – and the name stuck. Likewise, as the British press showed, to stress the effect of flu on the enemy, German forces had a useful propaganda effect, and so it was in the newspapers' – and the British government's – interest to highlight the 'foreign' cases, while down playing the effect of flu on British forces and civilians.

By 25th June 1918, it was recognised that the flu epidemic in Spain had already reached Britain. At a meeting of the Hitchin Rural Council in Hertfordshire that day, the councillors heard that 600 cases of flu had been reported at two different factories in Letchworth. The medical advice that was given here was to avoid going to cinemas and other crowded places, and to keep the mouth and nose covered if going out. During the previous nine days, 200 people with flu had been treated in the Belfast workhouse infirmary, with 45 cases reported there in just one day. Meanwhile, 40 workers at Cardiff's Central Post Office had been taken ill, and all schools in Huddersfield had been closed for a week due to the epidemic. By the end of that week, on 28th June, a public notice was put in the British papers, advising people of the symptoms – but it turned out that this was actually an advertisement for Formamints, a tablet made and sold by a company that also sold Sanatogen vitamins. The advert stated that the mints were the, "...best means of preventing the infective processes" and that everyone – men, women and children – should suck four or five of these tablets a day until they felt better. Even as people were dying, there was money to be made by advertising 'cures' – especially so as the medical profession seemed to be bereft of more practical ideas.

By early July, the epidemic was hitting the London textile trade badly, with one factory having 80 out of 400 workers go sick on one evening alone. It was said that in London, an average of 15 to 20 per cent of the workforce was suffering from the flu. In Egham, Surrey, 133 cases were reported in one school on one day, and many miners were ill, to the extent that the mining output in Northumberland and Durham was drastically reduced, while in one pit in Mansfield, Nottinghamshire, 250 miners were sick on one day. Urban centres were particularly badly hit, with Nottingham, Leicester



It was believed that spitting could spread Spanish flu, as this public health poster shows

and Northampton having a high rate of infection. It was speculated that this was because many of the workers in these areas were based indoors – "Persons engaged in outdoor occupations are practically immune."

Once one person was infected, others quickly followed. In the Convent of St Vincent de Paul in Westminster, a 13-year-old girl died of the flu – she was believed to have infected 62 others in the convent. Two ten-year-old boys died in Deptford, with the coroner at their inquest suggesting that they should have rinsed their mouth and nostrils every morning with salt and water to avoid getting infected. In Birmingham, doctors said they were at their "wit's end" and couldn't deal with the large number of patients – one doctor arrived at his surgery one morning to find nearly 200 patients waiting to see him. Manchester's dispensing chemists had to introduce a controlled queuing system because of the sheer number of people seeking remedies for their illnesses. The epidemic also hit in unexpected ways – one man due to be tried for bigamy at the Assize courts escaped prosecution because he came down with the Spanish flu. Whether he was too ill to attend court, or the court officials were terrified of catching his illness, is not known. Another man, Joseph Jackson, a discharged soldier, who claimed to have shell-shock, was sentenced to six months in prison for GBH after attacking a police constable while drunk. His defence was that he had been suffering from Spanish flu and a friend had advised him that drinking strong beer would cure him. He had followed the advice, with an unintended result.

In Sheffield, children under 14 were banned from going to the cinema, as local magistrates thought this move would help 'stamp out' the influenza epidemic. At a meeting of the Rotherham Board of Guardians, the clerk reported that the chairman was absent due to having the flu, as was one of the poor law guardians, and that five military nurses, the superintendent nurse, three nurses and an engineer were all sick locally. The clerk himself had just lost his sister to the Spanish flu.

"Bodies piled up to such an extent that it was said that families had to dig graves for their own relatives"

In Washington, DC, in 1918, the Red Cross Emergency Ambulance Station demonstrates its services

The lack of healthy workers affected all areas of daily life. Council workers had to become grave diggers; railway workers made coffins; and ambulance drivers found that their vehicles were now hearses. As with previous historical disasters – the plagues that had haunted England in previous centuries, for example – pressure was put on services by the sheer rate of deaths and the effect of the flu on those who survived.

The epidemic had rapidly become a pandemic, making its way around the world. In August 1918, six Canadian sailors died on the St Lawrence River from a, "...strange illness, which is thought to be the Spanish influenza." The same month, cases were reported among the Swedish army, then its civilian population, and also among South Africa's labouring population. Then, the following month, it reached Boston through its port, and by the end of October, nearly 200,000 people in the USA had died. Bodies piled up to such an extent that it was said that families had to dig graves for their own relatives. There was a shortage of farm workers, which affected the late summer harvest, and as in Britain, other services, such as the collection of rubbish, were put under pressure due to a lack of staff and resources.

Also as in Britain, Americans were offered conflicting and confusing advice about how best to avoid getting infected. They were advised not to shake hands with others, to stay indoors, not to touch library books, and to wear masks. Schools and theatres were closed, and a Sanitary Code was issued that made spitting in the streets illegal. At one point, the use of aspirin was blamed for causing the pandemic – when it might actually have helped the ill. As a result of World War I, there was a shortage of doctors in some areas, and of those who

FACTS

20-40 million
How many people are believed to have died in total worldwide

675,000
The estimated number of Americans who died

500 million
How many people were infected with the virus worldwide

12 years
The amount American life expectancy dropped by, as a result of the pandemic

228,000
The number of people in Britain who died of Spanish Flu

10%-20%
The mortality rate of those who were infected with the virus

1
The number of regions in the world that did not have an outbreak (Marajo, an island in the Brazilian Amazon delta)

2
The number of years the pandemic was at its peak (1918-19)

3,000
The number of Chinese Labour Corps workers who got flu-like symptoms

50,000
How many Canadians died of Spanish flu

were left, many became ill themselves. Makeshift hospitals were made out of schools and other buildings, and medical students had to take the place of some doctors.

Here, too, the flu virus hit people from all levels of society. The president, Woodrow Wilson, was said to have become infected; Cawthra Mulock, described as "one of the very wealthy men of Toronto" died in New York from the virus in December 1918. 40 per cent of the US Navy also became ill, and when four women sat down to a game of bridge one night, only one of them got up again the next day, the others having died of the flu overnight. It was estimated that 28 per cent of the American population was infected by the virus.

Elsewhere, the mortality rate was even worse. The pandemic spread to Asia, Africa, South America and the South Pacific, and in India, the morality rate was 50 deaths per 1,000 people – a shocking figure. As the Great War ended, the influenza pandemic became a new war that was being fought around the world. Back in Britain, in November 1918, the House of Commons heard a report from the War Department about how many British soldiers had been affected by the Spanish flu. In October, 421 members of the British Army had died in France from flu, and more than 1,000 from the pneumonia it had developed into. There had been nearly 25,000 influenza cases admitted to hospital in France the previous month. And this was just the figure for one month, for a specific occupation, in one part of one country. On a worldwide scale, the numbers were far larger and even more difficult to comprehend.

However, by the spring of 1919, it was being reported that the numbers of deaths from the Spanish flu were decreasing. This did not mean that it came to a quick end – in March 1919, immediately under a story about the decrease in cases, one Scottish newspaper reported the funeral of three members of the Wilson family of St Combs in Aberdeenshire, with a further child dying as the cortege was being taken to the churchyard. Their deaths left the family, "...practically wiped out by the scourge" of Spanish flu. Although the influenza pandemic eventually died out, it did so only after wreaking devastation in many countries, and showing the inability of the medical profession to do anything to halt its progress – in an echo of what had happened 500 years earlier, when the Black Death similarly wreaked chaos around the world.

Today, a woman sits in her flat in the suburban midlands. She is content; she is approaching her century, and has had a long and varied life. But she hides a more dramatic start to that life; her parents both contracted Spanish flu in 1918, when her mother was pregnant. It was her mother's life that was feared for most; but it was her father who died, three weeks before her own birth. Even today, in the 21st century, the Spanish flu pandemic is a reality that has shaped lives, and one that people remember having affected them and their families.

In Seattle, people weren't allowed to ride on the streetcars without wearing a mask

IN BRIEF

- **Death toll: 7**
- **Over Texas & Louisiana**
- **1st February 2003**

Columbia had made it to orbit and completed its mission, but on re-entry, disaster struck. A piece of foam had made a hole in the Shuttle at launch, leaving its crew with no hope of survival as it plummeted through the atmosphere.

SPACE SHUTTLE COLUMBIA

How seven astronauts lost their lives on Columbia in a mission that was doomed from the start

Inside mission control, there are three words you do not want to hear: "Lock the doors". Because when these are uttered, the mission has been a failure, and the painstaking task of recovering all data must begin. The last time these words were said for a manned mission on US soil was in 2003 – and they are words no one in mission control ever wants to hear again.

Space Shuttle Columbia broke up on its return to Earth after a two-week stay in space on 1st February 2003, killing all seven of its crew instantly. Alongside the Challenger disaster in 1986, it is the biggest loss of life in a single spaceflight tragedy. As shocking footage captured the break-up of Columbia on its return to Earth, the months and years that followed would reveal some shocking conclusions.

Columbia was NASA's flagship Space Shuttle. When the Shuttle program was first designed in the Seventies, Columbia was selected as the name of the first vehicle that would fly to space (although a test vehicle named Enterprise had flown in the sky previously), a name shared by both Captain Robert Gray's ship that explored the word, and the Apollo 11 Command Module that journey to the Moon.

This flight, STS-107, was to be its 28th mission, but it had been dogged by delays. The Space Shuttle had originally been intended as an all-purpose orbital vehicle, used to conduct science in the microgravity environment of space and take people of all walks of life on the trip of a lifetime – such as teacher Christa McAuliffe, who died in the Challenger accident.

By 1998, however, a new purpose for the Space Shuttle had been devised. NASA, together with its Russian counterpart Roscosmos, had decided to build a grand space station, the likes of which had never been seen before: the International Space Station (ISS). The Space Shuttle was given the job of ferrying most of the American components, or modules, for this huge $100 billion orbiting outpost, the size of a football field.

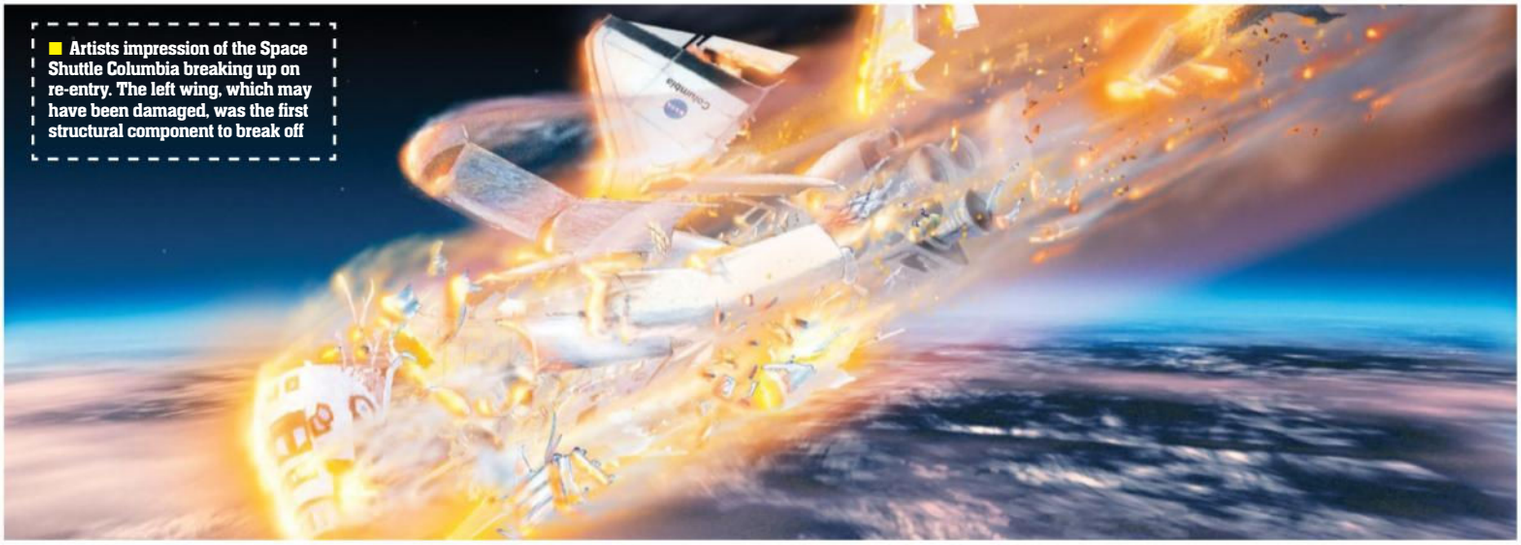
As such, science missions began to play second fiddle, and the large majority of Space Shuttle flights became either assembly missions – taking new modules to the ISS – or supply missions for the station, which began having crews stay for long durations in November 2000. These missions did not perform much – or any – useful science.

The scientific community were in uproar, fearing that they were missing a prime opportunity with the Shuttle to perform groundbreaking science in orbit. So, with a lot of pressure on NASA to justify spending $4 billion a year on the Shuttle program, STS-107 was selected to be a return of sorts to scientific missions.

On board, it would carry a new state-of-the-art research laboratory in its cargo bay, called SPACEHAB, which would be used to conduct 80 science experiments in orbit over about two weeks. To accomplish all these tasks, the team were split into two teams – red and blue – so that they could work around the clock, 24 hours a day, to complete the huge number of jobs allocated to them.

"If we didn't work 24 hours a day we'd be giving up eight hours of sleep time that could otherwise be

"The months and years that followed would reveal some shocking conclusions"



■ Artists impression of the Space Shuttle Columbia breaking up on re-entry. The left wing, which may have been damaged, was the first structural component to break off

used for science," STS-107 pilot William McCool said in an interview with the BBC prior to launch. "So the intent is to pack each minute of the 24 hours that we're on orbit with science."

Truth be told, these experiments probably weren't designed to endear the public; they were not the most exciting selections. One, for example, was an examination of dust above the Middle East. Another would extract oils from rose and rice flowers, to be used in perfume research. Aside from some experiments to observe weightlessness on a few animals, like spiders, there wasn't a huge amount to grab anyone's attention. But the mission was what the scientific community wanted, and after 16 days in orbit, it was declared a success.

However, the nature of the mission, being scientific and not part of the ISS Assembly phase, meant that it was continually pushed back in favour of what were deemed the more important missions. STS-107 was first planned to launch in May 2000, but it was forced to wait all the way until January 2003, with more than a dozen other missions taking place in between. For the crew of this mission, some of who were flying for the first time, it was a lengthy wait.

Finally, the date was announced: 16th January 2003. The crew prepared for this mission, the 113th flight of a Shuttle, just like any other. Columbia was rolled out to the launch pad at the Kennedy Space Centre in Florida aboard the giant crawler so iconic with these launches. Everything looked good. At 10.39am local time, it took off.

Prior to this launch, an issue had started to arise with the Space Shuttle and its large orange external tank that fed it fuel. This tank was covered in thermal insulation foam, which stopped ice forming when it was full of its fuel: liquid hydrogen and oxygen. If you look at a picture of the Space Shuttle attached to this tank, you'll note that it is attached by struts. Next to these were Bipod Foam Ramps, designed to reduce the aerodynamic stresses on the struts. But these small ramps were exposed, and on several flights prior to STS-107, parts of them had been observed falling off during launch. The idea that one of these might pose a significant problem to the Shuttle, though, was not seriously considered.

And so, STS-107 took off. But 82 seconds into the flight, the left Bipod Foam Ramp broke, and a chunk of this foam slammed into the left wing of the Space Shuttle. Although not picked up originally, high-resolution camera shots two hours after launch showed this happening. The launch continued unabated, with the Shuttle not experiencing anywhere near the intense heat of re-entry when going up.

The problem, though, was far more serious than anyone realised. In order to cope with the extreme heat of re-entry, the Space Shuttle had an advanced thermal protection system (TPS) on its underside, black tiles that could handle the 1,650 degrees


Material kicked up on the wing by the foam impact can be seen here

FACTS

82 Seconds into flight that fatal piece of foam hit Columbia's vital left wing

255 orbits successfully completed in the mission

15 days, 22 hours Time spent in orbit

6.6 million Miles travelled by Columbia while in orbit

29 Number of months until a Space Shuttle flew again

12,738 Speed in miles per hour at time of break-up

Celsius (3,000 Fahrenheit) heat. On its top were white tiles, used to insulate the Space Shuttle while in space.

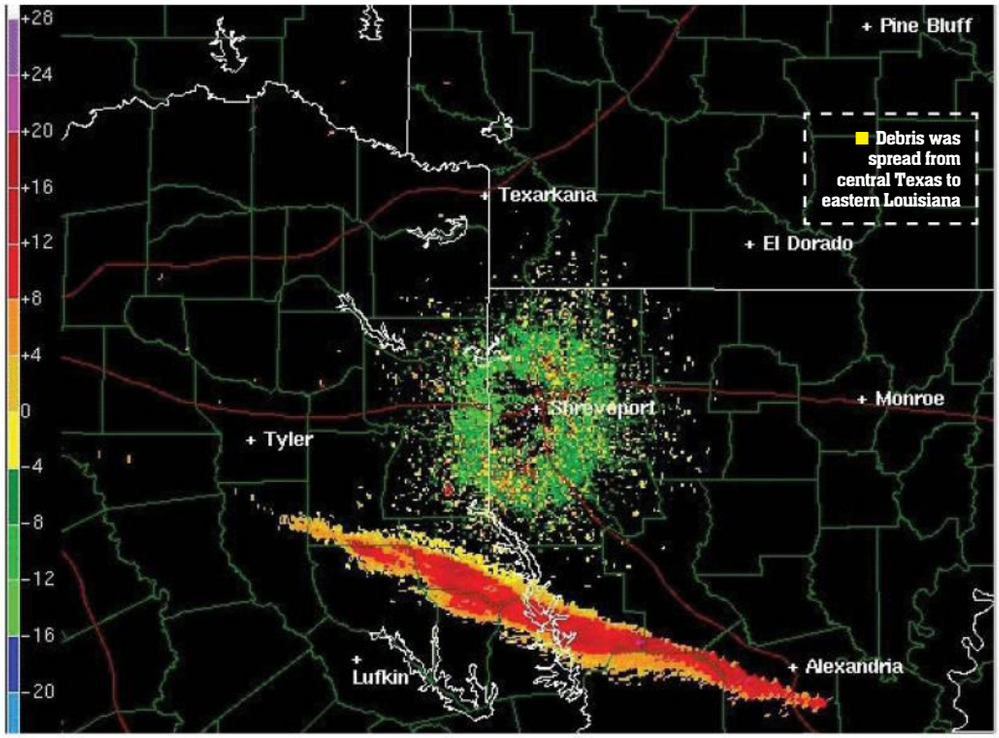
But on the leading edge of the wing was an ultra-strong material, reinforced carbon-carbon (RCC), also on the nose of the Shuttle, to deal with the intense aerodynamic forces of flight. Built to last, no one imagine that these could be severely damaged by a piece of falling foam. Following the accident, investigators re-enacted the foam strike to see if such an occurrence was possible. Taking the wing of another shuttle, they fired pieces of foam at it at the speeds and angle from the Columbia launch. The results were without doubt – the foam could easily have punched a hole in the wing.

At the time of the Columbia flight though, this was not known. So unbeknownst to the crew while they carried out their mission in space, they were essentially aboard a ticking time-bomb. With a hole punched through the wing, the Shuttle would not survive re-entry as hot gases flew into it.

While the seriousness of this problem was not fully realised, even if it was there was another problem. Although not widely discussed at the time, there was a rather ghastly scenario. If a hole had been punctured in the wing of the Shuttle, there was almost certainly no way the crew could be saved, barring an ambitious rescue mission with another Shuttle (see "Could Columbia's crew have been saved?").

"You know, there is nothing we can do about damage to the TPS," Jon Harpold, Director of Mission Operations, told Flight Director Wayne Hale, the latter revealed in a blog post online. "If it has been damaged it's probably better not to know. I think the crew would rather not know. Don't you think it would be better for them to have a happy, successful flight and die unexpectedly during entry than to stay on orbit, knowing that there was nothing to be done, until the air ran out?"

The grim scenario mission controllers were left with, therefore, was to continue with the mission and hope for the best. Touchdown was scheduled for 9.16am EST on 1st February 2003.



"Aside from a few worried faces, the thought of losing the Shuttle was not on many minds"

When the time came for re-entry, aside from a few worried faces, the thought of losing the Shuttle was not crossing many minds. And at first, things looked on track. Columbia was passing over the US on its way to a landing in Florida, flying on autopilot. While the landing itself was not making headlines anywhere, as this was supposed to be a routine flight, Shuttle enthusiasts watching the re-entry began to notice something going wrong. At a height of more than 210,000 feet, observers reported seeing chunks of the Shuttle fall off.

Inside Mission Control though, the problems were not yet obvious. During re-entry, which was past the point of no return to put the Shuttle back in orbit, the first indication of an issue was a dramatic drop in pressure of the left main landing gear. A faulty tyre itself was a problem for a runway landing, with a serious risk of the Space Shuttle crash landing and flipping.

Soon, though, temperature readings on the left side of the vehicle began to go haywire. Mission Control continued to assess the situation, trying to find out if the various anomalous readings were related. Columbia's last transmission came from

THE COLUMBIA INVESTIGATION

Following the accident, NASA convened a special panel to investigate the cause. Called the Columbia Accident Investigation Board (CAIB), it involved various figures from the military and NASA, in addition to many academic researchers, who pored through the available data to work out the cause of the accident, and what could be done to prevent something similar happening. The report was released on 26th August 2003, six months after the accident.

Some of the main findings from the report concerned when the crew were killed. The first, rather obviously, was the moment of depressurisation, as the orbiter was breaking up and the astronauts were exposed to the thin atmosphere outside. At this moment, some astronauts were not wearing suitable equipment like their helmets, which meant death was likely swift. "Although circulatory systems functioned for a brief time, the crew could not have regained consciousness upon descent to lower altitudes due to the effects of the depressurisation," the report noted.

It also found that the crew were not wearing proper restraints, which meant that as the orbiter began to lose control, the crew would have been thrown about. Their fate was sealed when they slammed into the ground; the parachutes relied on manual activation, something the report said should be changed.

The findings brought about a change in spaceflight safety, with a variety of new safety measures introduced for future Shuttle flights – including getting rid of the foam ramp that struck the wing of STS-107. In total, the CAIB made 29 recommendations to NASA.

"It is the team's expectation that readers will approach the report with the respect and integrity that the subject and the crew of Columbia deserve," the report concludes. It is free to read online via a quick Google search.

COULD COLUMBIA'S CREW HAVE BEEN SAVED?

We know that Space Shuttle Columbia itself, with the hole punctured in its wing, would not have survived re-entry. Even if the astronauts had spacesuits to use for spacewalks on board – which they didn't – it's unlikely they could have fixed the problem.

But there was one other, much more ambitious option. The Shuttle could not be saved, but the crew maybe could have been, thanks to another Shuttle being almost ready to launch.

Atlantis was scheduled to launch from Cape Canaveral on 1st March 2003, just six weeks after Columbia. On board the orbiting Shuttle, the crew had enough supplies to keep them alive for 30 days, beyond which they would suffer from asphyxiation.

While the launch of Atlantis was six weeks away, there was a chance that it could be sped up to just four weeks. This would have involved streamlining all the launch processes, like software checks, with technicians working around the clock. Such a mission would have been unprecedented, but not impossible.

Had the problem been properly identified by the second day of STS-107, preparations could have begun. With Columbia operating on severely reduced capabilities, Atlantis could have launched towards the end of that 30-day window. It would then have had to approach Columbia at right angles to keep the Space Shuttles close without their tails touching.

What would have happened next would have been drama of the highest order. Without spacesuits, and no way of docking the two vehicles, astronauts would have to be ferried to and from the two Shuttles. Atlantis would have been operating with a smaller crew of just four so that it could have fit all seven from Columbia on board, albeit tightly packed with 11 for the return.

Two astronauts from Atlantis would then perform a spacewalk over to Columbia, carrying two extra spacesuits with them. On each return trip, they would take members of the Columbia crew. But preparing to don a spacesuit and enter the vacuum of space takes hours; the entire procedure would have taken 48 hours before Atlantis attempted the return to Earth. Columbia, meanwhile, would have been programmed to burn itself up, unmanned, in Earth's atmosphere.

Of course, this mission never came to fruition. And had it ever been seriously considered, it would have posed a new dilemma. Would NASA have sent four more astronauts to space, knowing the problem with the foam had not been resolved and that they could lose 11 people, rather than seven?

Commander Rick Husband; "Roger, ah," he said, before being cut off.

Although breaks in communication were normal for re-entry, this was lasting much longer than expected - beyond a minute. Incredibly, those in Mission Control were still not clear of the situation as debris started raining down along an area 300 miles (480 kilometres) long, from East Texas into Louisiana. In total, more than 2,000 pieces of debris were recovered. Pieces smashed into roofs and onto farms, but thankfully no one was injured. Horrifyingly, some people reported finding human remains, including a heart, a skull, arms and feet.

"There was a hand, and a foot, then a leg from the knee down," Norwood Deputy Faron Howell told the *Telegraph* in an interview in 2003. "One of my men found a human heart. The biggest piece was a torso, the upper bit with the chest ripped in half. We think it was all from one astronaut... It was mangled real bad. You couldn't even tell if it was a man or a woman."

"The Columbia disaster remains NASA's last loss of humans during a spaceflight mission"

Mission Control continued in vain to communicate with the crew of Columbia. "Columbia, Houston, UHF comm check," the communicator Charles Hobaugh repeated over and over. But the worst had happened. Columbia had disintegrated. Its crew had likely been killed almost instantly by the depressurisation. The flight director, Leroy Cain, gave the command everyone was dreading.

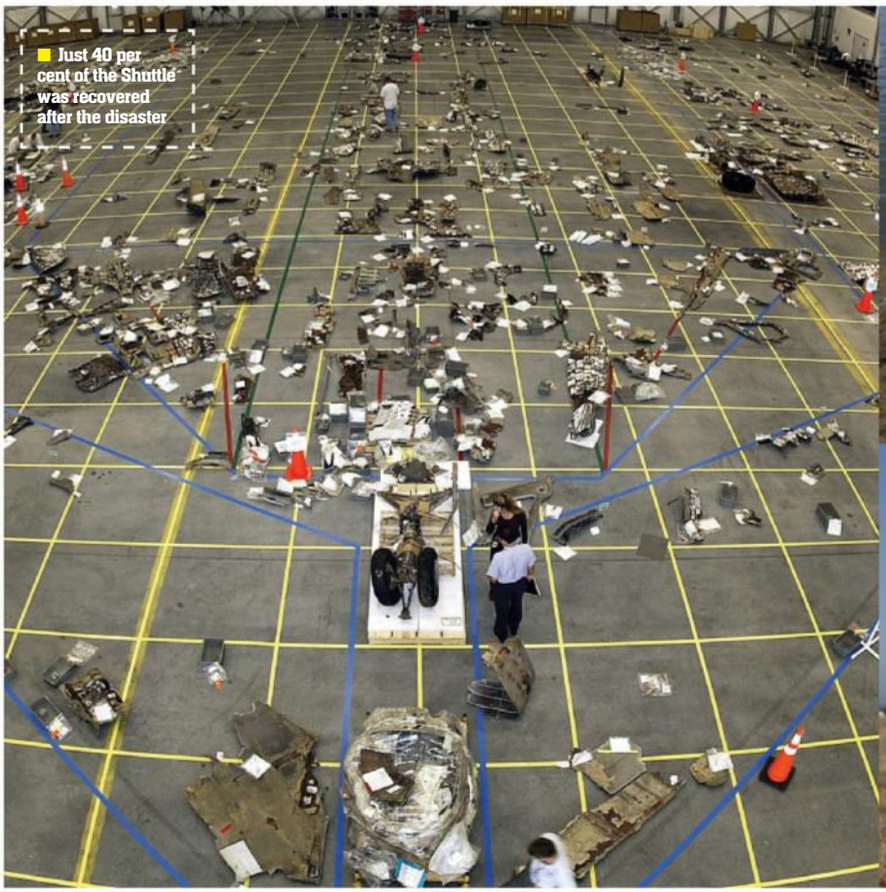
"Lock the doors."

As mentioned earlier, this phrase means that everyone in mission control had to collect all of the data they had. No outside communication was allowed. Grief counsellors were brought in to calm people. The investigation had begun.

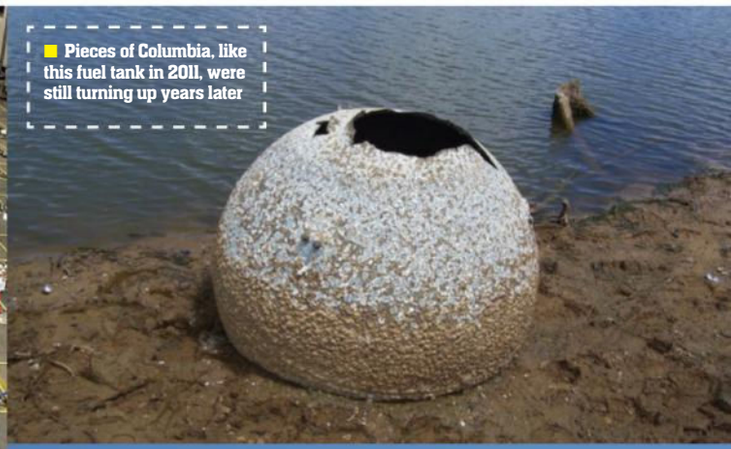
Unlike the crew of Challenger, who may have survived more than two minutes after the launch explosion, Columbia's crew were unlikely to have suffered for long. The resulting investigation concluded that the astronauts were probably aware of the problem for only 41 seconds, and when the break-up of the Shuttle began they would have lost consciousness almost instantly.

One consequence of the Columbia accident was that the foam ramp that had broken off and struck the Shuttle's wing was found to be not absolutely necessary for launch, so to prevent any foam strikes like this in future, it was scrapped. Thankfully, no more serious events occurred.

In the aftermath, it was also decided that no Shuttle could ever launch again without a valid rescue plan. So for every launch after Columbia's final flight, a back-up Shuttle (with the designation STS-3XX) was ready and waiting to perform a rescue mission, if required - that is, aside from the



■ Just 40 per cent of the Shuttle was recovered after the disaster



■ Pieces of Columbia, like this fuel tank in 2011, were still turning up years later

■ Firefighting teams walk shoulder-to-shoulder through fields outside Corsicana in north Texas

last shuttle mission in 2011, STS-135, which would have used Russian Soyuz spacecraft instead in the event of an emergency. But no contingency mission was ever needed.

The Columbia disaster remains NASA's last loss of human life during a spaceflight mission. Numerous memorials have since sprung up around the world and beyond, including the landing site of the Spirit rover on Mars.

Columbia, though, was markedly different from the Challenger accident. On the latter, the issues were known prior to launch, and engineers had attempted to halt the ill-fated launch before it went ahead, but to no avail. On Columbia, that same level of mismanagement was not so apparent – not many had expected the foam debris to be capable of such a serious incident. Sadly, this belief was false.

Following the Columbia mission, there were just 22 more Shuttle missions – across orbiters Atlantis, Endeavour and Discovery – before the fleet was retired, with NASA shifting its focus from low-Earth orbit to missions beyond, such as back to the Moon and Mars. Columbia marked one of NASA's darkest days, and brought to an end an ambitious program that never really reached its full potential in the years it was active.

Nonetheless, every single crew member flew on missions they believed would better mankind, and propel us further and further to the stars. The Columbia crew were no exception.

COLUMBIA'S FIRST FATALITIES

The loss of seven crew on a single flight was devastating. But you might be surprised to learn these were not the only tragedies associated with the Space Shuttle Columbia.

In 1981, five technicians were setting up the Shuttle for a ground test. They were performing a routine procedure, where nitrogen was used to purge the engines of the Shuttle of oxygen, so that no spark could accidentally start a fire. The Shuttle operated fine on the ground full of nitrogen, so tests could be carried out.

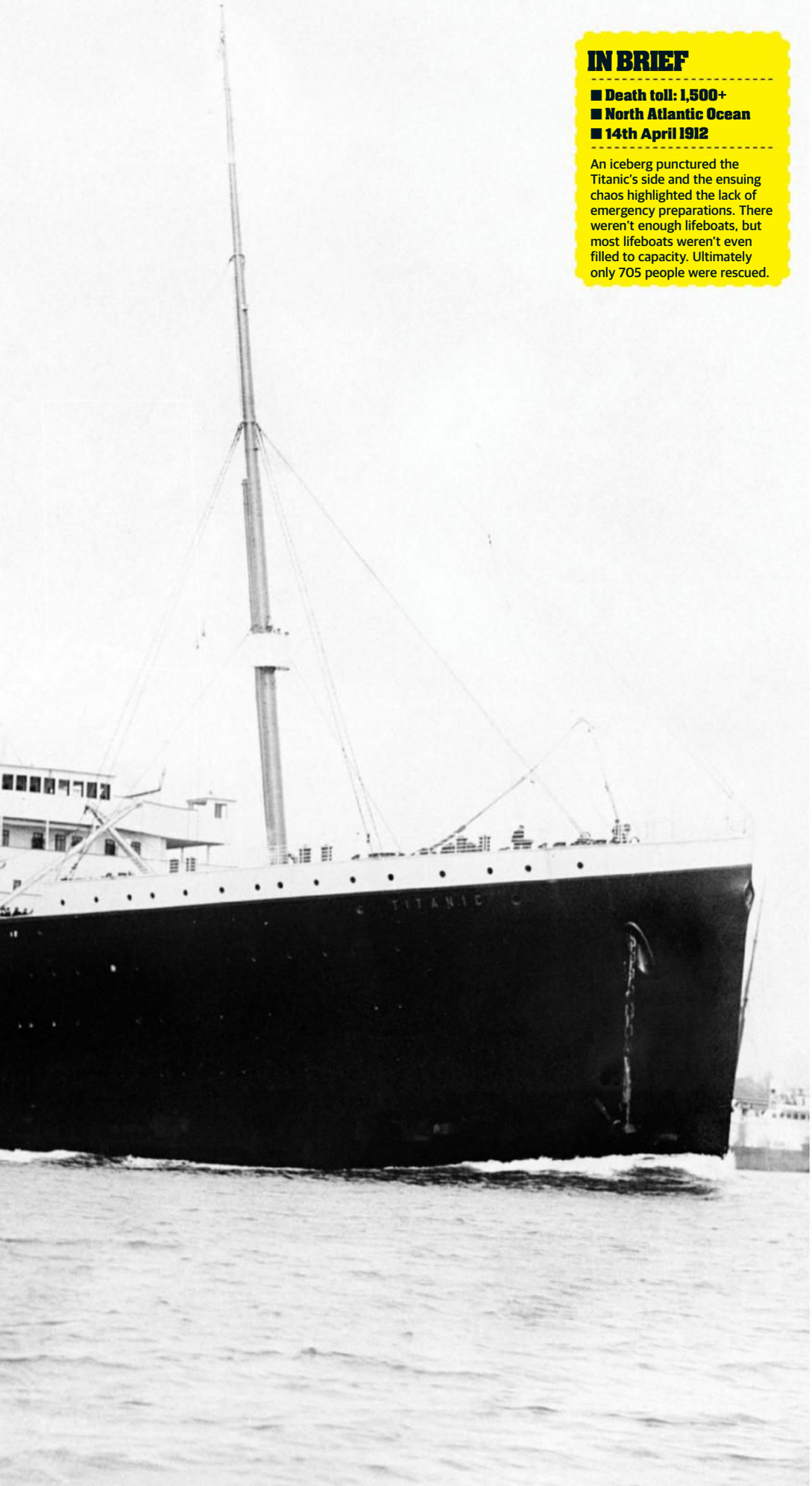
Nitrogen, though, can be deadly if inhaled directly. And, on 19th March 1981, five technicians incorrectly thought they had the all clear to enter the Shuttle after this test. Not knowing Columbia was still full of nitrogen, they immediately lost consciousness.

Another worker saw what had happened, and rushed to put on an air pack to help them, dragging them from the compartment. Only three of the five men could be revived.

Complicating matters, an ambulance sent to help was held and searched for seven minute by security guards, who did not know there was a problem. Ultimately, one worker died at the scene, and another on the way to the hospital.

THE SINKING OF RMS TITANIC

It was the first word in luxury travel but the Titanic disaster shook the world



IN BRIEF

- **Death toll: 1,500+**
- **North Atlantic Ocean**
- **14th April 1912**

An iceberg punctured the Titanic's side and the ensuing chaos highlighted the lack of emergency preparations. There weren't enough lifeboats, but most lifeboats weren't even filled to capacity. Ultimately only 705 people were rescued.

At 12.15pm on 31st May, 1911, the largest ship that had ever been constructed was launched into the water for the first time, causing a not-inconsiderable wake in the River Lagan in Northern Ireland as all 52,000 tons of it entered the water. Over 20 tons of soap and candle wax were spread on the shipway to help lubricate the great beast's entry into its natural habitat where, like a seal labouring on the land before gliding in the water, all of a sudden the great monster changed from an inert piece of metal into something imbued with grace and power.

The launch might have occurred without a champagne bottle smashing onto the bow of the ship, but this was a rare moment lacking in pomp. The chairman of White Star Line, the prominent British shipping company behind this new venture, J. Bruce Ismany, was in attendance as well as other important businessmen. This was an exciting time for the company as the *Titanic* – the name derived from Greek mythology meaning gigantic – was actually only one of three of their new Olympic-class ships that were designed to bring a new meaning to size and luxury when it came to sea travel. The other two ships – *Olympic* and *Britannic* – would, along with the *Titanic*, usher in a new age. On the same day the *Titanic* was launched, the *Olympic* successfully finished its sea trials. A new age of sea travel had truly begun.

The *Titanic* was the flagship and the ship everyone clamoured to get a ticket to travel on; *Titanic* was the name on everyone's lips. This last point would be realised, more so than the company could ever have wished, but for markedly different reasons, when the ship sunk in the cold and murky waters of the Atlantic Ocean and claimed with her the lives of over 1,500 souls.

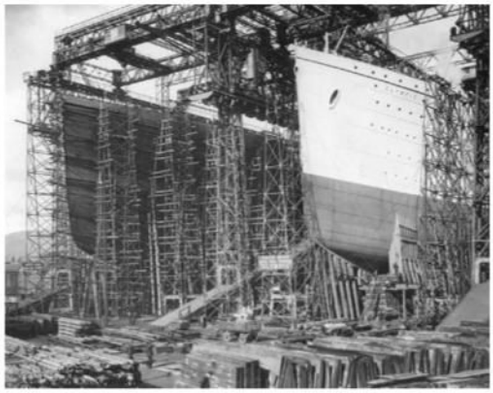
The *Titanic* and her sisters had been built by White Star Line to compete with the ship builders Cunard, which had built the fastest ships ever constructed. In the early-20th century, before air travel had entered its golden age and become available to others than only the super-rich, travel by the oceans was the main form of transport from country to country, and indeed, continent to continent. White Star Line decided to compete on not just speed but also on luxury and extravagance. Their new ships were forged in Queen's Island in the industrial docklands of Belfast and no expense was spared – the estimated cost of the *Titanic* was $7.5 million (£4.6 million), an absolute fortune.

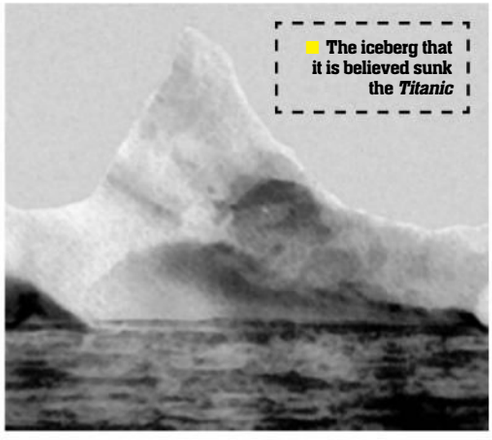
The *Titanic* was constructed at the same time as the *Olympic*, with both ships taking around 26 months to make. It would be generous to even label the safety precautions as adequate, although to be fair to the makers of the ship, they were fairly standard for the time and injuries were probably made worse due to the fact that no ship building of this size had been attempted before. Construction of the *Titanic* began in the spring of 1909 and was carried out by the men of Harland and Wolff,

the firm given the mammoth task. During its construction just under 250 injuries were recorded, with 28 of these classified as 'severe', where limbs were severed by the gigantic cutting machinery or workers were crushed on the building site by stray pieces of metal. Official figures put the death count during the making of the ship at nine; these would not be the last deaths caused by the ship made to be the last word in luxury.

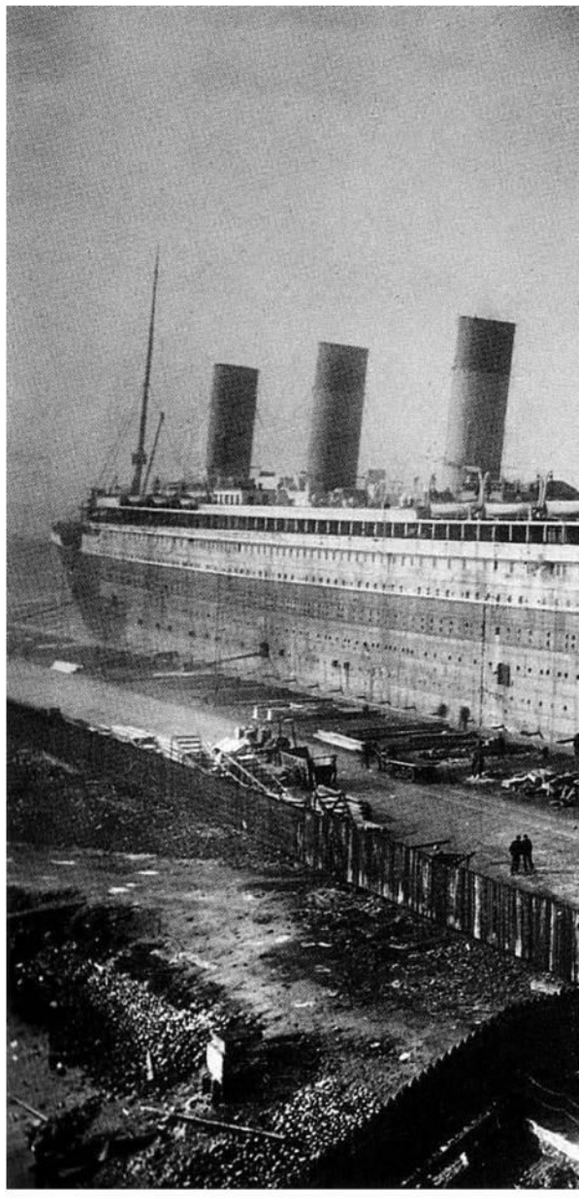
The docks at Southampton on 9th April 1912 were a flurry of activity; high-class gentlemen and ladies arrived in motorcars with servants carrying their luggage filled with the finest clothes, silent-film stars milled about and families looking for a new life and adventure on the other side of the world in the United States tried to control their excitable children from running around the deck. The ship may have been luxurious but it was financially unfeasible to fill a ship this size with only the upper class, so different-class tickets were available: A first-class ticket cost between £30 ($50) and £660 ($1,080) - or £1,875 ($3,060) to £41,000 ($67,000) in today's money. Second-class tickets were available from £12 ($20) - £750 ($1230) in today's money, and buried out of sight in the bottom of the ship, a third-class ticket could be purchased from £3 ($5), which equals £190 ($310) today. The largest third-class cabins could hold ten passengers, a world away from the resplendent luxury of first class.

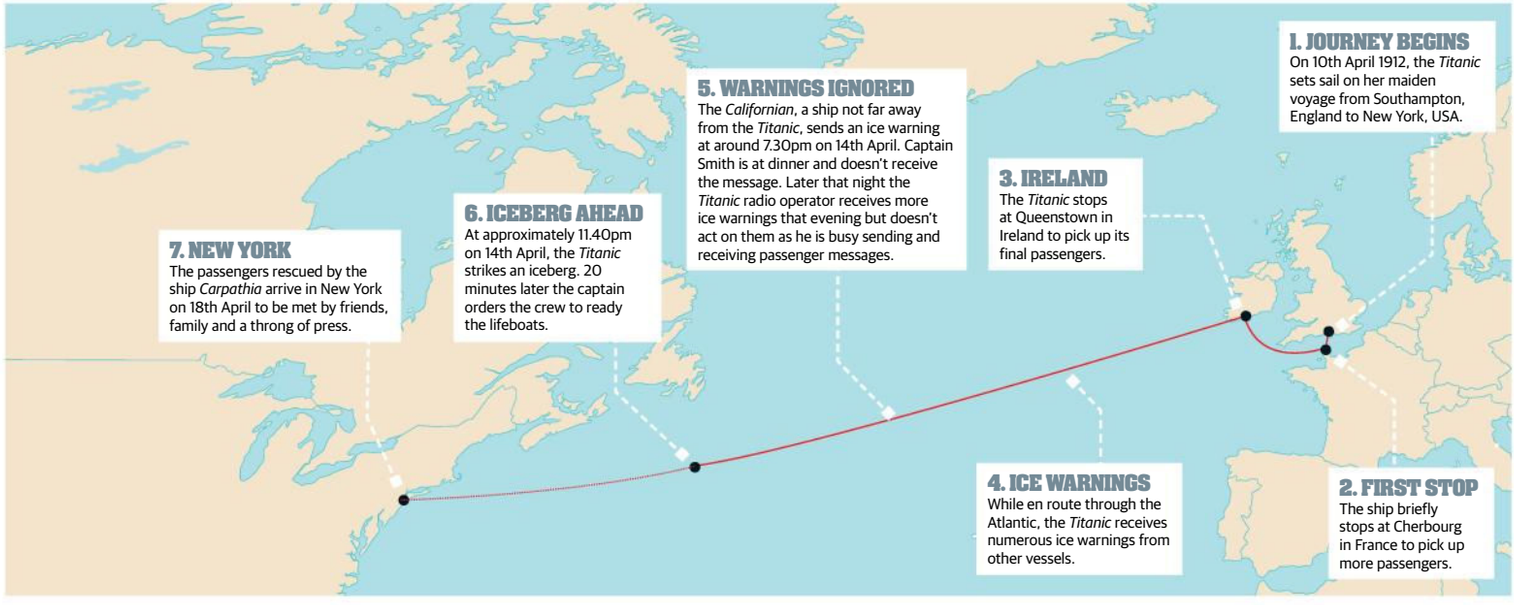
At 12pm the next day the passengers boarded the ship and its journey began. There were 2,223 people on board (1,324 passengers), of which there were 13 couples on their honeymoon. The journey almost got off to an inauspicious start when, after pulling away from Southampton docks, the wash from the giant ship's propeller caused a laid-up ship called *New York* to break from her moorings and swing towards the *Titanic*. Quick action from Captain Edward J Smith helped avert a premature



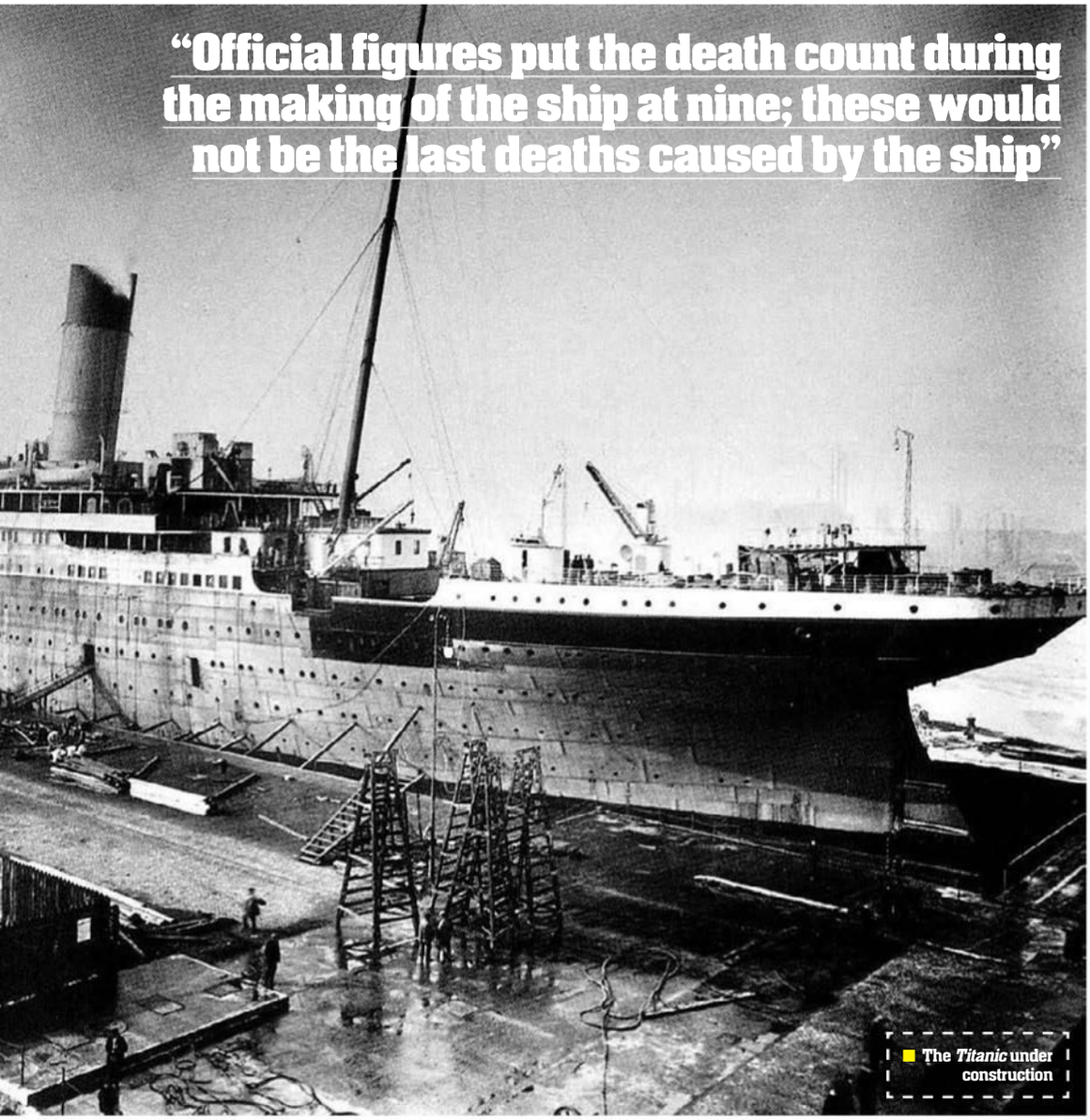


The iceberg that it is believed sunk the *Titanic*





"Official figures put the death count during the making of the ship at nine; these would not be the last deaths caused by the ship"



The *Titanic* under construction

end to the maiden voyage. The unfortunate incident was seen by those thus inclined as an ill portent for the journey ahead.

The ship's itinerary called for the vessel to stop at Cherbourg and Queenstown (Cork) before making the journey across the Atlantic to New York City, expected to take seven days. The ship was equipped with enough amenities for a much longer voyage, though. Among the facilities on board were four restaurants, a swimming pool (entry fee was one shilling); two barber shops, two libraries, one fully-equipped gymnasium and one photographic darkroom. The ship held 15,000 bottles of ale, 8,000 cigars, 40,000 eggs, 36,000 apples and 57,000 pieces of crockery. The ship also carried 20 lifeboats, which was more than the law required but too few to safely evacuate all of the passengers on the world's largest ship, with the lifeboats capable of holding approximately 1,178 people. However, this fact was not given much thought or care, and why should it have been? The *Titanic* was a triumph of modern technology.

It is unclear whether anyone ever explicitly referred to it as the 'unsinkable ship' but this sentiment was certainly the general feeling at the time. It has been reported that a *Titanic* crew member remarked to an embarking passenger: "God himself could not sink this ship!" Part of this confidence was that the ship's double-plated bottom and 16 watertight compartments designed to close if water entered them were believed to offer the utmost in security. Several years before he took command of the *Titanic*, Captain Smith was quoted as saying: "I cannot imagine any condition which would cause a ship to founder. I cannot conceive of any vital disaster happening to this vessel. Modern shipbuilding has gone beyond that." This tragically sums up the overly confident attitude of the time.

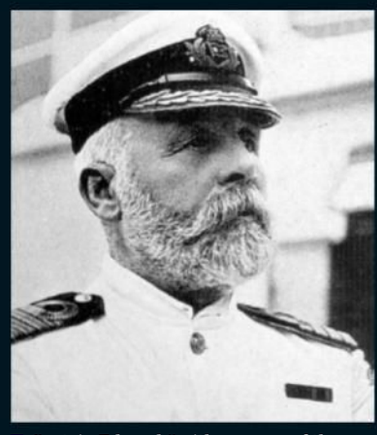
With the voyage under way and the ship generally travelling full steam ahead, the ship's

"WOMEN AND CHILDREN FIRST"

Captain Edward J Smith (1850-1912) was one of the White Star Line's most experienced captains. Aged 17 he travelled to Liverpool to begin his apprenticeship on the ship *Senator Webber* before he joined White Star as a Fourth Officer in 1880. He quickly rose through the ranks and seven years later was given his first command.

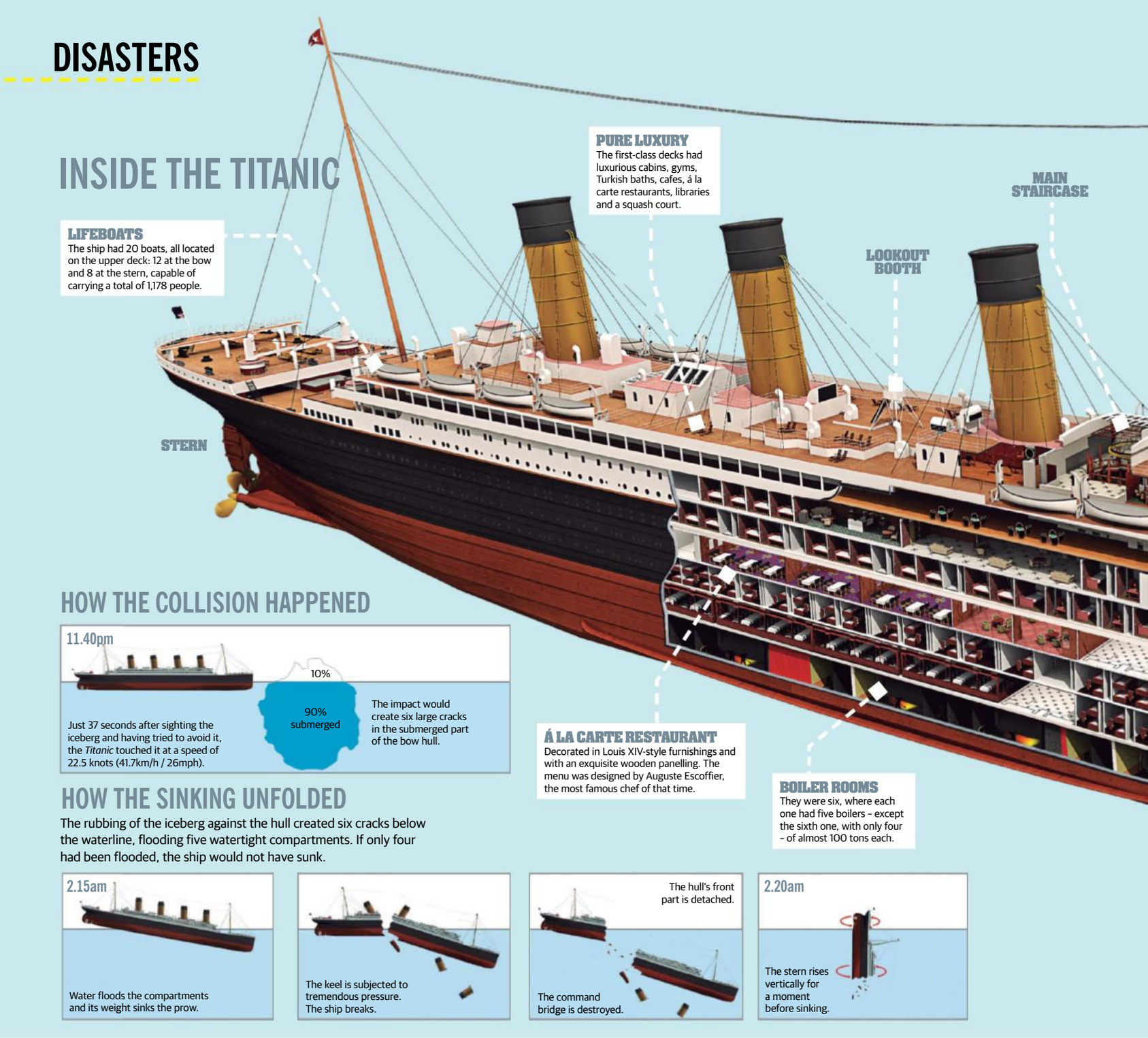
Smith became commodore of the White Star fleet in 1904, after which it became routine for him to command the line's newest ships on their maiden voyages and it is said that he gained such a reputation as a captain that some passengers would only travel on ships where he was in command. However, this is not to say that he had not had previous incidents; in 1911 while captaining of the *Olympic*, the ship collided with a British warship, leaving Smith's vessel to limp back to port. The Royal Navy blamed the ship, saying that due to its massive size it had created a suction that pulled the warship into her. It was an indicator of how difficult it could be to operate these new gigantic and unwieldy ships.

By 1912, Smith had served at sea for 40 years, with 27 years in command. However, when the *Titanic* collided with the iceberg this experienced captain did not cover himself in glory, and many believe that he panicked. He did not issue a general call for evacuation, he withheld information from his crew – for example, Quartermaster George Rowe did not find out the ship was sinking until over an hour after the collision and phoned the bridge from his watch station to ask why he had just seen a lifeboat lower into the water. The captain did not supervise the loading of the lifeboats and according to later testimony it was the second officer who actually suggested getting the women and children into the lifeboats before others. Captain Smith, aware of the enormity of the situation, retreated into his shell and appeared to simply wait for the inevitable. The great captain, as legend dictated, went down with his ship.



Captain Edward Smith was one of the world's most experienced captains

INSIDE THE TITANIC



HOW THE COLLISION HAPPENED

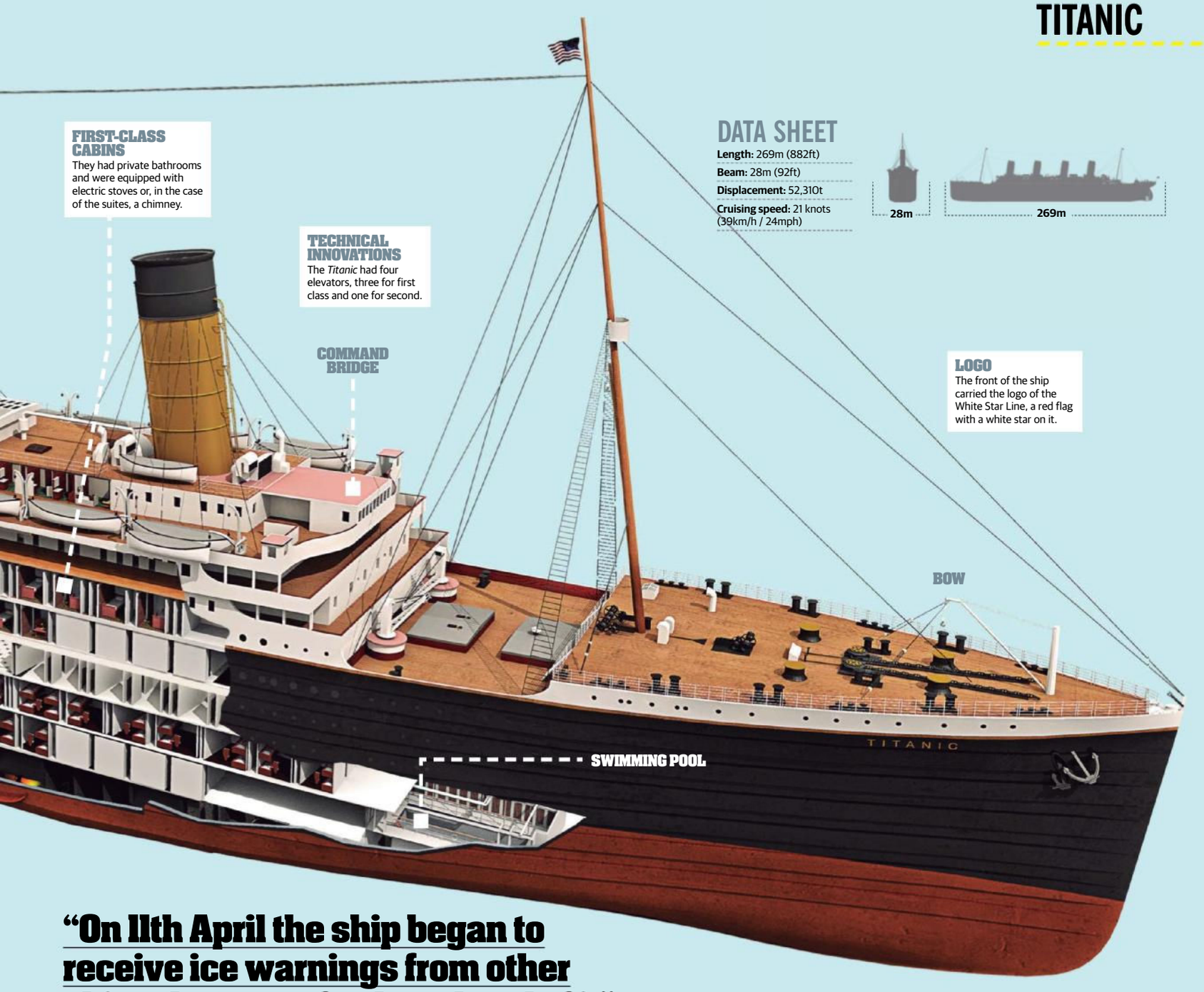
HOW THE SINKING UNFOLDED

The rubbing of the iceberg against the hull created six cracks below the waterline, flooding five watertight compartments. If only four had been flooded, the ship would not have sunk.

two radio operators were busy. Senior operator John George Phillips and his junior, Harold Sydney Bridge, had agreed a system where the radio was operated for 24 hours a day. They also had one of the most powerful radio systems in the world, giving them a 640-kilometre (400-mile) transmission range with a large antennae between the two masts. A large part of the radio operators' job was to pass on and send messages from the crew and this responsibility – and perhaps pressure to keep some of their rich and privileged passengers content – contributed to the disaster. Starting 11th April, the ship began to receive ice warnings from other ships further ahead of her in the voyage and by the time of the disaster they had received at least five warnings.

Perhaps the most striking of these both occurred on 14th April. First, the radio operators overheard an ice warning that was passed onto the bridge but was not brought to Captain Smith's attention as he was at dinner. The second incident occurred when the ship Californian – which was approximately 32 kilometres (20 miles) from the *Titanic* – reported to the *Titanic* that she was blocked in by ice. Phillips, the radio operator on duty at the time, signalled back to tell him to stop bothering him, that he was busy. The *Californian*'s radio operator switched his radio off and went to bed. Less than an hour later the *Titanic* collided with an iceberg.

Would things have been any different if the message had been passed onto the bridge and the captain? With the benefit of hindsight it seems like an astonishing neglect of duties by the radio operator. However, the captain and other senior members of the crew were well-aware of the ice warnings, as several had been passed on previously. It's unlikely that even if this final warning had been relayed that anything different would have occurred. What we do know is that at 11.40pm, lookout Frederick Fleet spotted an iceberg immediately ahead and alerted the bridge. First Officer William Murdoch ordered the engines to be put into reverse and for the ship to be steered around the obstacle but it was too late. Just 30 seconds after the iceberg had been spotted the giant ship careered the starboard side of its frame into the iceberg, cutting open a series of holes below the waterline.



"On 11th April the ship began to receive ice warnings from other ships that were further ahead of it"

The actual collision wasn't that strong, indeed, many of the ship's passengers who had already retired to bed remained asleep, their dreams undisturbed. However, after a survey of the ship Captain Smith realised that serious damage had been done and that water was rapidly being taken on. The *Titanic* was sinking.

At the British enquiry following the accident, Edward Wilding (chief naval architect for Harland and Wolff), calculating on the basis of the observed flooding of forward compartments 40 minutes after the collision, testified that the area of the hull opened to the sea was, "Somewhere about 12 square feet (1.1 square metre)." Modern ultrasound surveys of the wreck found that the damage consisted of six narrow openings in an area of the hull covering about 1.1 to 1.2 square metres (12 to 13 square feet). Regardless, the ship was going down.

Less than 20 minutes after the iceberg had been struck, lifeboats were launched into the water and the radio operators had started sending out a distress signal. The standard distress signal at this time was the 'CQD' signal - 'CQ' was the signal to other ships to stop transmission and pay attention and the 'D' was added to indicate distress. In 1906, the signal 'SOS' was created for the characters' simplicity in Morse code: three dots, three dashes and then three dots. The radio operators on the *Titanic* used both distress signals.

The *California* - the ship that had earlier warned the *Titanic* about ice - was by some distance the doomed vessel's nearest ship, although how far

One of the most luxurious rooms aboard the *Titanic*, Stateroom B-59, decorated in Old Dutch style

away it was has become a topic of hot debate. The radio operators called to it, saying: "Come at once. We have struck a berg. It's a CQD, old man." However, neither this nor any of the other messages they sent was met with a response. A later, more desperate message read: "We are putting passengers off in small boats. Women and children in boats. Cannot last much longer. Losing power." Not getting any response from the *California* on the radio the *Titanic* began firing their distress rockets into the air. However, the ship still did not respond and at a later enquiry apprentice officer James Gibson admitted that they had seen the lights but, after attempting to contact the *Titanic* through Morse code - not radio - and getting no reply it was decided that no action should be taken.

On the doomed boat itself, the crew members were attempting to take control of the situation but most were criminally unprepared. On that very morning Captain Smith had planned a lifeboat drill but for an unknown reason it was cancelled. If it had gone ahead it is likely that many lives could have been saved as no one on the ship seemed to be aware how many people each of the lifeboats could safely hold, and what the correct boarding procedures were. The captain's call for 'women and children first' was, in the main, observed and the result was that many men stood on the slowly sinking ship and could only watch as lifeboats were filled to half capacity before they were lowered. The first lifeboat that launched (Lifeboat 7) only carried 24 people, despite having a capacity of 65. The fewest-recorded people carried on a lifeboat through was one that only took 12 even though it had a capacity of 40.

This photograph shows the last lifeboat successfully launched from the sinking ship

Hearses line up on Halifax wharf, Canada, to carry *Titanic* victims to funeral parlours

It may have been women and children first but to even have a chance of getting off the ship social class was all-important. The third class were located in the depths of the ship and had to navigate a mini-maze in order to get out onto the deck. The boat had no public address system and while the first-class stewards were responsible for only a few

LEGACY OF THE TITANIC

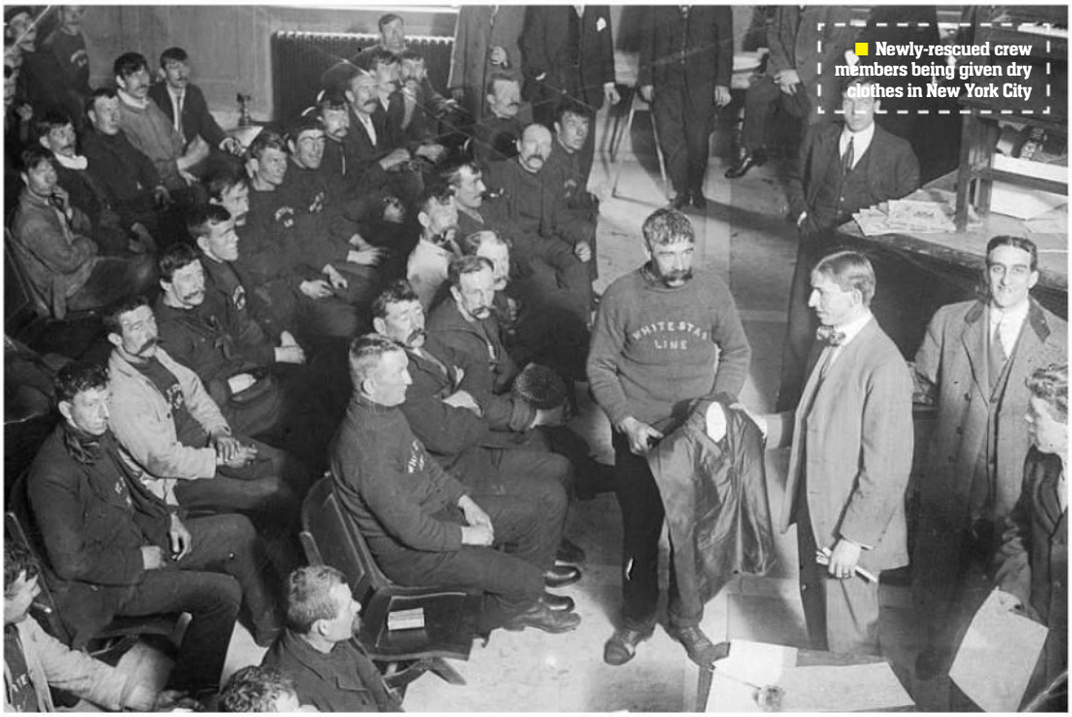
The ship was seen as the very embodiment of modern technology and that it sunk was a shock to everyone. The disaster ended the career of the White Star Line chairman, J Bruce Ismay, who was on board but survived on a lifeboat. Many believed he should have, like the captain, gone down with his ship and in 1913 the board of directors denied his request to continue as chairman.

Separate inquiries were held in the US and Britain to identify the cause. The US committee was seen in Britain as an attack on the British shipping industry but both committees reached similar conclusions and, as a result, improvements to safety were made. These included a decree that ships had to carry enough lifeboats for those aboard, that radio communications on passenger ships would be operated for 24 hours and that the firing of red rockets from a ship must be interpreted as a sign of distress.

There are a number of *Titanic* museums and memorial monuments across the world; from an 18-metre (60-foot) lighthouse built in New York, to memorials in Southampton, Liverpool and Belfast. The ship was constructed in Belfast and it is here that a memorial statue and a garden was opened in 2002 around the original *Titanic* monument, which contains 15 bronze plaques listing in alphabetical order the names of all those who died on *RMS Titanic*.

The ship has left behind a cultural legacy, with a number of films and books about the tragedy. At the ship's 100th anniversary a number of events marked the event, such as a cruise ship that retraced the journey and took part in a memorial service at the spot where it sank. This event led to accusations of bad taste, but left no doubt that the Titanic still captures the public's imagination.

The *Titanic* signature building in Belfast is a museum dedicated to the iconic ship



Newly-rescued crew members being given dry clothes in New York City

"That very morning Captain Smith had planned a lifeboat drill but for an unknown reason it was cancelled"

cabins the second and third-class stewards had much greater numbers to take care of. In the third class the best passengers received was simply being informed of the need to come up on deck. In some cases it was much worse. *Titanic* survivor Margaret Murphy was a third-class passenger at the time. She wrote later: "Before all the steerage passengers had even a chance of their lives, the *Titanic*'s sailors fastened the doors and companionways leading up from the third-class section ... A crowd of men was trying to get up to a higher deck and were fighting the sailors; all striking and scuffling and swearing. Women and some children were there praying and crying. Then the sailors fastened down the hatchways leading to the third-class section. They said they wanted to keep the air down there so the vessel could stay up longer. It meant all hope was gone for those still down there."

The first lifeboat entered the water at 12.45am, although the crew had initial difficulty in persuading passengers that they would be safer on them rather than the 'big ship'. Soon after the first, a number of other lifeboats entered the freezing water while crewmen on the *Titanic* fought a desperate and ultimately doomed mission to expel the water seeping quickly in. It soon became apparent to all that the ship was sinking and the reactions of the crew and passengers was striking in their variance. Some couples separated, with the women taking a lifeboat and the men staying on the ship but others refused to part. The co-owner of the department store Macy's, Isidor Straus, was reportedly told by his wide Ida: "We have been living together for many years. Where you go, I go," and the pair sat down in deck chairs and waited for whatever hand fate dealt them. Many members of the *Titanic* band continued to play their instruments.

At just after 2.00am the angle the ship was lurching at became more acute, causing a giant wave to crash along the forward part of the ship and wash many passengers into the sea. Sadly, they were only the first of many to enter the water that night. The ship snapped in half and the stern began to lift into the air and, to add to the terror, the lights soon flickered off, plunging the ship and its remaining passengers into total darkness. Soon afterwards the ship would be in darkness forever, as it plunged into the water to make its way to the bottom of the ocean.

Those lucky enough to be on lifeboats had to spend hours floating in them, waiting for rescue, listening to the death throes of those not fortunate enough to get on a boat. These poor souls died in the freezing waters, crying out in anger, despair and fear as debris from the 'greatest ship in the world' floated alongside them. With an estimated temperate of –2 degrees Celsius (28 degrees Fahrenheit), some would have died instantly from the shock of the cold, while for others death by hyperthermia would have been agonizingly slower. Mercifully, most slipped away after 20 minutes. Now those in the lifeboats had only silence for company and it was several hours until the *Carpathia*, travelling full steam ahead throughout the night at considerable risk, arrived at 4.00am.

The survivors entered their rescuing ship by any means they could; some had enough strength left to climb up the rope ladders that were dangled down, others were hoisted up in slings, with mail sacks being used for children. For a lucky few the ordeal was over. The *Carpathia* arrived in New York in the evening of 18th April to be greeted by a throng of 40,000, among them family members of passengers and some of the world's media. It was only several days after the ship had docked that the sheer scale of the disaster became public knowledge. Trips would have to be made to try to collect those who had perished and inquiries would be held to determine the cause of the disaster. The 'unsinkable ship', the great marvel of modern technology that was a symbol of man's advancement and skill had vanished into the depths, claiming the lives of over 1,500 souls. The world would never be quite the same again.


TOWNSEND THORESEN

HERALD OF FREE ENTERPRISE CAPSIZES

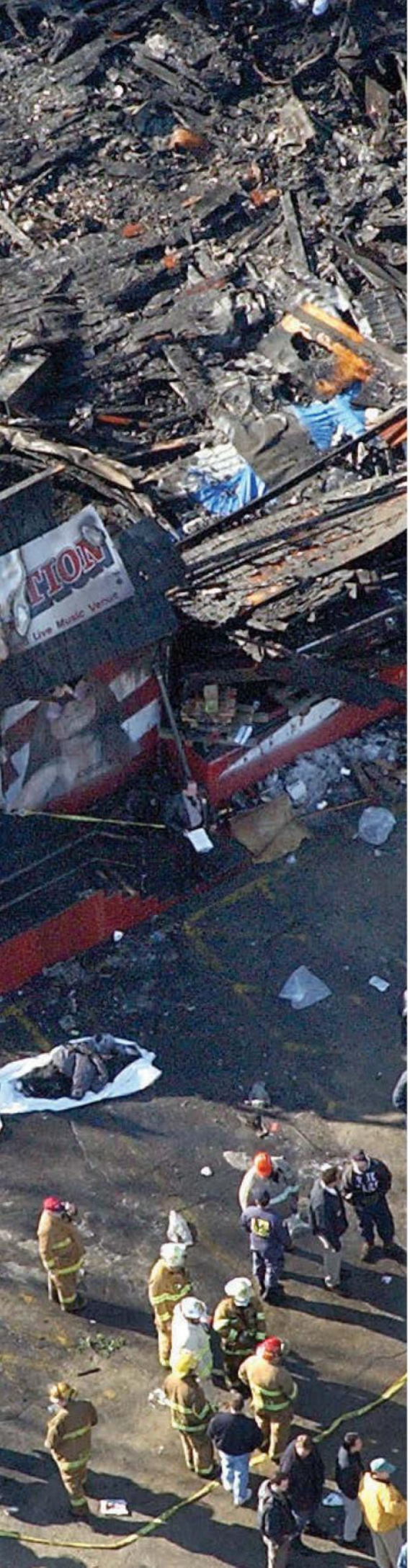
1987 BELGIUM

A series of staff failures led to the sinking of the *Herald of Free Enterprise* car ferry. Departing the port of Zeebrugge, Belgium, before ensuring its bow doors were closed, the car deck flooded instantly and the vessel capsized 23 minutes later. A sandbar prevented it from sinking entirely but 193 of the 539 passengers and crew perished, many from hypothermia. The resultant court inquiry ruled their deaths as unlawful.

IN BRIEF

- **Death toll: 100**
- **Rhode Island, USA**
- **20th February 2003**

Out-of-control pyrotechnics set off during a nightclub concert just seconds after it had begun ignited the flammable sound-proofing of the venue, causing fire to spread at a rapid rate.



THE STATION NIGHTCLUB FIRE

Michael Ricardi and James Gahan shared a love of glam metal music. But when they went to watch a favourite band, only one returned

The exuberant crowd punched and waved their arms in the air, exhaling their excitement in a cacophony of screams, yeahs and whoops. Their eyes were transfixed on Jack Russell, lead singer of the group Great White, as he bounced around the stage, lifting and jerking his microphone to each strain of his band's guitars, his body almost silhouetted by the lights behind him.

It was 11.07pm on 20th February 2003, and Great White were just seconds into their headline set at The Station nightclub, a one-story building on 211 Cowesett Avenue, West Warwick, Rhode Island. Michael Ricardi and his friend, Jim Gahan, were among the packed crowd of music fans who had looked forward to seeing the Eighties heavy metal band take to the stage. The room may have felt cramped, but they were determined to enjoy themselves.

To welcome the band, just as they began to play their opener *Desert Moon*, tour manager Dan Biechele lit pyrotechnics that created a huge fountain of sparks flowing upwards in three directions. But just as Russell started to sing, the crowd noticed that something wasn't quite right. The urethane foam covering the polyurethane sound-proofing on the walls of the drummer's alcove at the back of the stage had ignited.

Michael Ricardi is one of the lucky escapees from the deadly blaze

Yet at first no one paid much attention to it. Some of the crowd asked if it was part of the show, and others agreed that it must be. But the hand waves turned to frantic fingerpointing as concerned fans soon jabbed in the direction of the fire. It was becoming clear that the flames were taking hold. "The flames had already crept up the foam padding wall, and they were beginning to catch on to the ceiling," recalls Ricardi. Some fans were edging towards the doors.

As carbon monoxide and hydrogen cyanide gas started to be released in the burning process, there was a fleeting expectation that sprinklers or one of the venue's staff would put the fire out. But there were no sprinklers, and the fire began to grow more intense. "It was like everything happened simultaneously – the fans were desperately trying to get Jack Russell's attention," Ricardi says. "He literally had no idea what was going on just a few feet behind him." But then realisation dawned. "The band stopped playing abruptly. It was at that moment you could tell something was seriously wrong."

Ricardi and Gahan had met two years earlier at Nichols College in Dudley, Massachusetts. Ricardi had been wearing a t-shirt that had been issued for the 'Power to the People' tour by the American rock band Poison, and it caught Gahan's attention,

Taken from the horrific video footage of the fire in progress

leading to a strong friendship. The pair went on to host their own college radio music show, and they watched many bands together. That night in Rhode Island was typical of what they did, but they were not prepared for what happened next.

There were some audible shouts of "Go, go, go!" and hands began to wave in the opposite direction towards the front doors of the venue. At this point, the fans were calm as they headed for the exits. Ricardi and Gahan were certain that everything would be okay, and that they were not in any immediate danger.

"I can't speak for many people in the crowd," Ricardi explains. "All I can tell you is that myself and Jim didn't think it was that big of a deal. In our minds, we were patrons of this club and would be kept safe. We could have never imagined going to a rock concert would result in fighting for our lives. I just remember seeing everyone move their way towards the back of the venue, in a relatively calm manner."

Yet after 30 seconds of Great White appearing, the situation was significantly worsening. "Oh my god – fire," someone shouted above the rising, panicked voices. The stage was by now a bright yellow inferno, and the air was pierced by the sound of the fire alarm. The pace of the crowd quickened, and people looked for any way out. Some of those closest to the stage attempted to exit through the nearby west-exit door, which had been used by the band and their encourage. But witnesses say they were pushed back by security and told to head some six metres back to the front door, which was becoming heavily crowded.

Time began to slow as thick black smoke bellowed through the venue. But getting out proved to be difficult. The Station nightclub – a 4,484 square-foot wooden structured building that had been built just after the end of World War Two – had lots of space. The former pub and restaurant was split into a number of areas, with a main bar, dart room, kitchen, toilets and a narrow front entrance area within a few steps of the main club floor, but anyone leaving through the front would have to go past a single door, through a set of double doors and onto the entrance ramp, which had a barrier running along its side. This was the route most people would take, and it was very cramped.

Ricardi began to make his way, believing Gahan was close behind. "I've been told there is no way I was in that building for more than two minutes, tops," says Ricardi. "I honestly have no concept of time while still in the building." Some people involuntarily dropped to the floor to catch their breath and escape the incredible, scorching heat that was searing the low-ceiling of the club. Flames began to fall to the ground. Some people were on fire.

"Once the toxic smoke filled the room, you literally couldn't see anything"

The situation was worsening and, in the pitch-black – the lights having popped in the heat – and with smoke bellowing from all corners of the building, the air was pieced with fearful screams and cries. "Once the toxic smoke filled the entire building, you literally couldn't see anything. The only thought in my mind was getting out as soon as possible," Ricardi says.

Panic had set in, and as burning debris from the ceiling also began to fall, people started to pass out. "It was painful. I can remember feeling the heat burning my back, which sustained second degree burns," recalls Ricardi. Fans were being trampled in the rush to escape. They started to head for any possible exit, many leaping through windows, but others had become trapped inside, unable to move.

At the front of the building, bodies began piling upon bodies following a desperate scramble down the narrow corridor that led to the exit. There were loud pleas for help. Those who had escaped were able to head back to the doors and pull some of those people to safety, even though the choking smoke was bellowing over their heads. After six minutes the area around that door was also choked with smoke. According to fire captain Russell McGillivary, many of the victims were found in the front door area that night.

WERE LESSONS LEARNED THAT NIGHT?

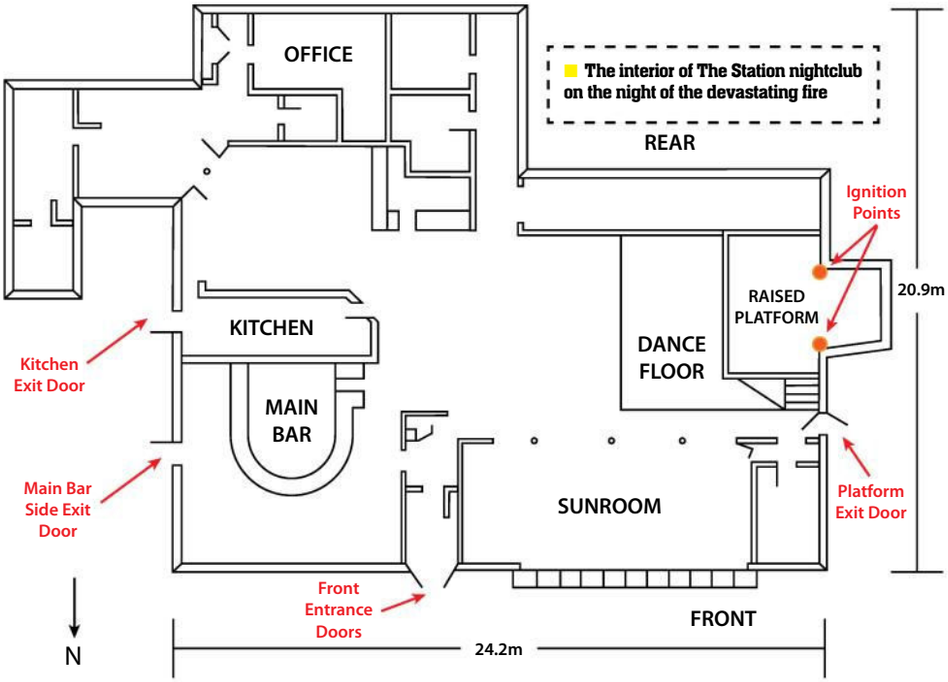
In the aftermath of the fire, numerous investigations took place to discover the full truth of what had happened on that terrible night. As well as charges of involuntary manslaughter, there were numerous civil settlements, as well as wrongful death and personal injury cases.

Attorney John Barylick represented victims, and built up a solid picture of that night from the various statements he gathered. He has written a book called *Killer Show*, and he tells us that lessons have still to be learned.

"We can be pretty slow learners when it comes to overcrowding clubs and using pyrotechnics inappropriately – witness events in Russia, Thailand and Brazil since The Station fire." Indeed, in 2009, 150 people died in the Lame Horse fire in Perm, Russia, while 66 were killed in the Santika Club fire in Bangkok, Thailand; 242 died in the Kiss nightclub fire in 2013.

"The Station fire was not the result of any single blunder; rather, it resulted from multiple bad choices made by individuals in the interest of profit," Barylick continues. "That's the discouraging fact. The encouraging corollary, however, is that just one person making the right decision can break the entire chain of causation, thereby averting tragedy. The lesson of the Station fire is that fire marshals, club owners, entertainers and promoters each have the power to save lives – it just requires putting safety before profit."

Today, Barylick also lectures about the fire. "I tell fire inspectors that they have a vitally important job, but an unusual one in this respect. If they do their job really, really well and prevent the next Station nightclub fire, they'll probably never know it. But if they don't do their job well, and the next Station fire occurs on their watch, they'll never be able to forget it. It usually gets their attention."



The interior of The Station nightclub on the night of the devastating fire

Outside, there were people wandering confused and blackened by the smoke, sobbing as they pressed snow – which had fallen prior to that harsh winter night – tightly onto their scorched skin to try and relieve the pain. As dozens of paramedics and emergency crews arrived, people were taken away on stretchers, and others walked over to a triage centre for treatment. Badly injured victims were still being pulled out of the building as firefighters were working on extinguishing the fire.

Ricardi was one of the lucky ones, but it changed his life. "My only thought was finding Jim and getting as far away as possible," he says. But his friend passed away that night, one of 100 people who died as a consequence of the fire. A further 230 were injured, while 132 escaped unharmed. It was the fourth deadliest nightclub fire in the history of the United States.

"I was in shock when I got out of the building," Ricardi said. "Everything just felt so surreal. Even though logic would dictate something very bad was taking place, I just wasn't able to comprehend the reality of it." He has written about that night in his book, *Just A Thought Away*. He uses it to recall the fire, his experiences of the aftermath and the effect it had on him.

But the story of that terrible night didn't stop when the flames were extinguished. Biechele was sentenced to 15 years in prison in 2006, 11 years of which were suspended. He ended up serving half of the four-year jail term, and he subsequently left the music business.

Brothers Jeffrey and Michael Derderian, who owned the nightclub, were also charged with involuntarily manslaughter. Michael was handed the same sentence as Biechele (he was granted his release in June 2009, while his brother received a ten-year suspended sentence, three years' probation and 500 hours of community service). The siblings are now co-directors of the volunteer, non-profit Station Education Fund, which helps support the near 80 children who lost at least one parent in the fire.

It is a night Ricardi will never forget. "The place was overcrowded, the exits weren't announced. It just didn't seem like the venue wasn't prepared for an incident like this," he says of a venue that was licensed to hold 404 people. And he hopes that lessons have been learned. "Unfortunately, there were many extenuating circumstances in play that night, but a tragedy like this can happen anywhere," he adds, stressing the importance of venues in following the local fire laws and regulations and having trained staff who know the established emergency processes well.

"From a personal standpoint, I'm always very aware of my surroundings now," he says. "If I don't feel safe in a venue, I leave, no questions asked. And I'll let staff know why I did."

HOW DO CROWDS COLLAPSE?

Many of the victims of The Station nightclub fire died or suffered injuries when the density of the crowd became too great as they sought to escape. It is understood that when more than five people are packed into one square metre, freedom of movement is restricted. Any more than eight and the situation becomes very dangerous.

As the crowd began to move towards the front entrance in order to escape the blaze, it formed a bottleneck in the corridor, yet those at the back naturally continued to move forward. "A slip, trip or fall can then create a collapse," says Keith Still, professor of Crowd Science at Manchester Metropolitan University. "All it takes is one person to stumble or two or three trying to get through the door and getting jammed."

Death is caused not by panic, stampede or crushing, but compressive asphyxia. "Five people on top of one is enough for the forces to be lethal," Still explains. But why do people generally tend to head in the same direction, even if they are not being directed to?

"It's a form of Ellsberg Paradox – the paradox of choice – and perception of risk," Still says. "'I know the way I came in, I know that route, I don't know what's behind the door marked Emergency Exit. I don't know where it goes and I don't know if it's open or safe'. The initial choice is based on the perception of risk. Others then follow."

This makeshift memorial to the victims of the fire was created at the former location of the nightclub

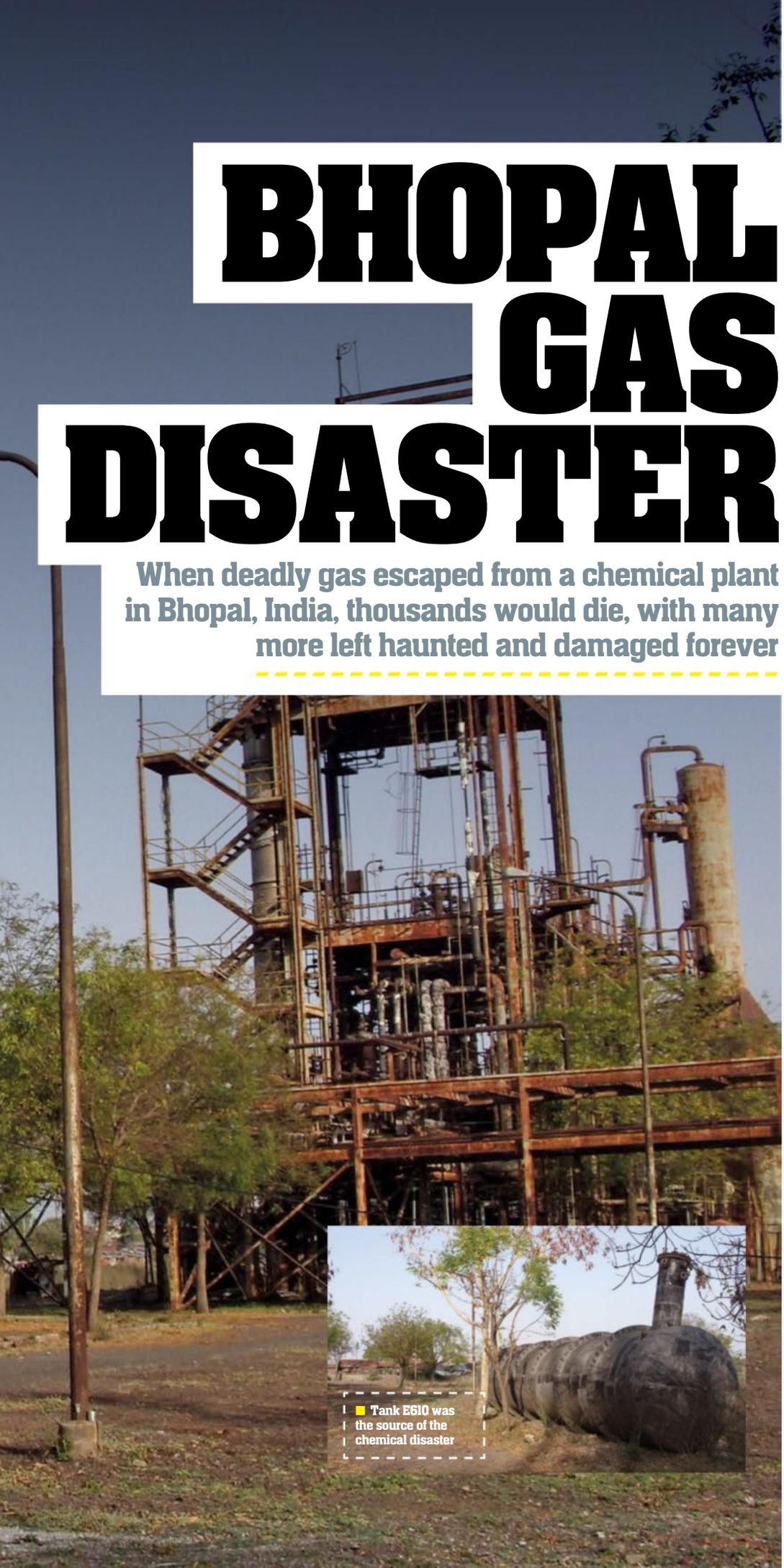
IN BRIEF

- **Death toll: 5,200**
- **Bhopal, India**
- **2nd December 1984**

The deadly gas leak at the Union Carbide plant was the worst industrial disaster in the world. The tragedy shone a light on the notion of corporate social responsibility, and more than 30 years later the people of Bhopal are still suffering.

BHOPAL GAS DISASTER

When deadly gas escaped from a chemical plant in Bhopal, India, thousands would die, with many more left haunted and damaged forever



Tank E610 was the source of the chemical disaster

It's 1am in the bustling city of Bhopal, Central India. Many of the nearly 1 million residents of the city are asleep. Some are still awake, maybe looking out at the stars on the chilly, clear night.

A fog envelops the night sky, emanating from the Union Carbide Chemical factory. The white vapour, propelled by winds that rolled across the city that night, made its way through the tightly packed abodes in the slum alleyways. These ramshackle buildings had no real ability to protect the people inside, and the chilly weather on the night meant this toxic fog fell and settled close to the ground.

The people desperately needed protection from this fog, which was a deadly chemical – Methyl isocyanate (MIC) – leaked from the pesticides plant. People were woken by the odour of the deadly gas, stinging the eyes and causing violent coughing.

In the streets outside people were heard screaming "Run! Run!" The streets were thick with people running for their lives. It was a stampede. There were hundreds who couldn't escape – the frail, the ill and the very young. These people died in their beds, overcome by the caustic fumes.

The effects of the MIC gas on humans were beyond belief. Pregnant women had spontaneous abortions, and people effectively drowned as their lungs burned and filled with blood. Some were blinded from the caustic effects of the gas blowing in the wind.

Aziza Sultan was one of the thousands who ran for her life that night. "A thick white cloud enveloped everything, reducing the street lamps to thin points of light," Aziza recalled.

"I saw lots and lots of people running, they were screaming for help, vomiting and falling down unconscious."

Aziza was two months pregnant at the time of the tragedy, and shockingly she miscarried in the middle of the street.

Just hours earlier, workers on the night shift at the plant detected a gas leak. It was 11.30pm when they noticed the smell of MIC, and saw a leak, their eyes watering from the gas.

The workers set about implementing some of the safety precautions, like using water spray to neutralise the leaking chemical. They took their scheduled tea break and discussed what to do next.

There had often been problems with the equipment at the plant. A processing unit was sometimes problematic – it would clog up with deposits of MIC.

To fix the clog, workers would flush it out with water. At 9.30pm on 2nd December, workers did just that. It took a while for it to come out the other end. However, a backlog of water had travelled through an adjoining pipe and into an MIC tank. A safety device called a slip line should have been in place to stop water flowing where it shouldn't when workers washed the pipes.

DEADLY GAS

Methyl isocyanate (MIC) is a toxic compound. Discovered in 1888, it is used in the production of pesticides, rubbers and adhesives. When humans are exposed to the chemical, the effects on the body are disastrous. Autopsies of Bhopal victims revealed that MIC breaks the walls of the lungs, causing people to ooze white foam from their mouth. Effectively, people drown in their own body fluids. Exposure to MIC also causes fatal pulmonary edema, and exposure in large amounts kills the cells of the cornea, producing permanent blindness.

After autopsies were performed, the tragedy revealed the changes to the lungs, cerebral oedema, tubular necrosis of the kidneys, fatty degeneration of the liver and necrosis of the organs. The damage to women's reproductive health was devastating. A research article on the health effects of the disaster revealed that in a sample of 865 pregnant women who lived within one kilometre of the plant at the time of the gas leak, almost half of the pregnancies did not result in a live birth.

The slip line was a critical piece of equipment that had not been in place due to the plant's management being forced to cut costs. A maintenance supervisor whose job was to make sure the equipment was kept in safe working order had been laid off before the incident occurred.

The Union Carbide plant opened in Bhopal in 1969, making fertiliser and pesticides. Wholly operated by a subsidiary of the global corporation Union Carbide India Ltd, the plant used MIC to make an insecticide called Sevin. The use of MIC was a cost-efficient one-step process. However, the presence of the toxic gas meant that safety procedures had to be impeccable, which they were not at the Indian plant. By 1983, the company was making huge losses because Indian farmers weren't buying pesticides in the quantities expected.

"By the time the sun rose, the streets of Bhopal were littered with bodies"

There should have been one last measure to avoid a deadly reaction in the event that water encroached the storage tanks. A method involving inert nitrogen gas pumped into the tanks should have formed a protective layer between the MIC and the rest of the plant.

The absence of that basic but crucial safety cover was what allowed the water to mix with MIC and create the deadly, toxic reaction.

At 12.30pm, a control room operator, Suman Dey, noticed that the pressure indicator for the gauge on tank 610 was stuck on the maximum pressure reading. Upon investigating the tank area, he was left in no doubt that something very bad was happening – he heard a safety valve pop, and the tank was rumbling and throwing off a lot of heat.

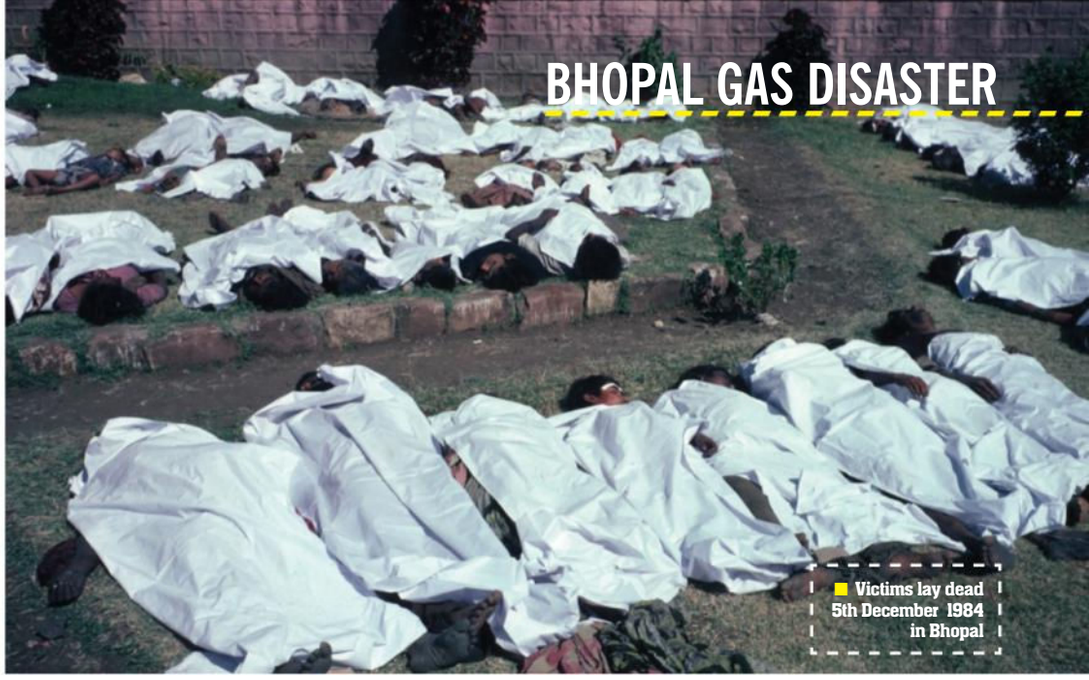
"There was a tremendous sound, a messy boiling sound, underneath the slab, like a cauldron," Dey would recount. "The whole slab was vibrating."

At this point anything the workers did to stem the disaster was futile. Even the safety measure of using a spare tank to relieve the pressure in the affected 610 tank was not an option. The spare tank was not empty, so the workers couldn't transfer quickly enough the MIC there to minimise the impact of the gas leak.

The police and army were deployed to help manage the chaos. By the time the sun rose, the streets were littered with bodies – both people who'd died on the spot, and the survivors, many with cloths over their weeping, damaged eyes, who had literally survived the night from hell. The gas had cast a pall over the city for one hour before it was dispersed by the wind. The toxic fumes had stopped spewing out from the 120-metre tower stack.

The workers at Hamida Hospital, overwhelmed by the people in need, had no idea what kind of gas had erupted from the chemical plant, and would not find out until several days later. They had no idea of how to treat the people who were coughing to death and screaming in agony, and could

Medical staff give eye drops to a victim of the gas



Victims lay dead 5th December 1984 in Bhopal

only provide symptomatic treatments for the injuries. The hospital was the closest to the site of the plant, so most people fled in its direction. They had to crowd multiple people into single beds, and as the death toll rose at an alarming rate, trucks arrived to take the bodies to cremation grounds and morgues. Charities and disaster organisations quickly established tent clinics to try and help the overwhelmed local and federal government efforts.

Over in the US, Union Carbide Chief Executive Officer Warren Anderson addressed a press conference telling the media: "It doesn't sound like something that could be inadvertent, and could be a deliberate action."

Union Carbide believed that a disgruntled worker had sabotaged the equipment and purposely pumped water into the tanks, fully aware of the deadly consequences.

Trades unions watching closely from the US sought an independent opinion. Michael Wright, a representative from American Steelworkers (now known as United Steelworkers), who was also the powerful union's health and safety boss, travelled to India as part of a fact-finding delegation on behalf of two international labour federations – the International Confederation of Free Trade Unions, and the International Federation of Chemical, Energy and General Workers' Unions.

The delegation were not able to gain work visas from the Indian government to conduct the investigation, so they had to speak to workers – including those who were on the scene when the accident occurred – in clandestine meetings. Eventually, Wright was able to get his hands on the operating manual for the plant.

A fault in the line – a leak – had been there for at least 20 days prior to the disaster, but there was no record of this in any logbooks. The fault was discovered when a worker, speaking to *National Geographic* for a documentary on the disaster, said that he'd seen workers attempting to pressurise tank E610 on 30th November two days before the disaster struck.

"But they weren't able to pressurise it... it means there's a leak in vent line. For more than 20 days it has not been holding pressure."

The delegation's official report said the workers thought the water entered the tank by "a roundabout route through malfunctioning valves and the jumper line."

American process safety expert Kenneth Block wrote a report called 'Learning From Bhopal: Preventing Catastrophic Process Releases' that investigated what went wrong at the plant and how the disaster could be prevented from ever happening again.

Block said that Bhopal forever changed the way that industry approaches the Process Safety Management of highly hazardous and explosive chemicals. "Systems that should have prevented the release, including a refrigeration unit and alarms failed," Block said.

"None of the safety equipment capable of containing the potential release, or at least minimising its consequences, had worked either."

A number of pieces of safety equipment had failed on the night, including the Vent gas scrubber, which wasn't operational. The scrubber had been

THE 'SABOTAGE' DEFENCE

From the outset, Union Carbide Corporation (UCC) claimed that the disaster was an act of sabotage by a disgruntled worker. The corporation's case was that the only way that so much water could get into the MIC storage tanks – causing the deadly chemical reaction – was through deliberate action.

However, this theory didn't take into account the other safety failures on the night. UCC conducted its own 16-month investigation, and said it found altered log books, indicating a cover-up, and had scientific evidence that the leak could not have happened the way the Indian Government or the independent labour delegation investigation said it did.

"All the evidence points to a deliberate act by a person on the scene as the only plausible explanation for what happened," Union Carbide chairman Warren Anderson said in a statement to employees on the one-year anniversary of the disaster.

The former Indian employees of the plant were deeply offended by this claim. This, according to legal experts, was a strategy by UCC to avoid paying damages. If the gas leak was caused by deliberate action then the company believed it would not be compelled to take responsibility. However, Indian officials said even if it was sabotage, the corporation must still be held responsible.

One of its main pieces of 'evidence' was that a pressure gauge supposed to be on the 610 tank was missing on the night of the disaster, leaving an opening in the tank that allowed water in.

The Carbide investigators said one employee told them that he'd noticed the pressure gauge was missing, but didn't think it was important enough to mention to government investigators at the time. He said he'd replaced the gauge the morning after the gas leak.

When Union Carbide Corp made the 1989 settlement in the Indian Supreme Court in 1989, it only settled the civil case. There was no provision for a clean-up of the environment, nor was there healthcare for anybody affected by its poisons.

Elderly survivors of the disaster protest for justice

FACTS

27 Tons of the deadly MIC gas escaped

7000 Animals died from gas exposure, mainly livestock like buffaloes, cows and goats

US$500 The average amount survivors received from the Union Carbide $470 million damages settlement

120,000 People in Bhopal still suffering the effects of the gas exposure

under maintenance, and the gauge was broken, so it was not clear if it was working. The contraption was meant to use a caustic solution of sodium hydroxide to wash the deadly gas and remove its toxicity.

Also not operational was the flare tower used to burn gas. A piece of worn piping had been taken out and not replaced. This safety system would have prevented the release of the deadly gas.

Similarly, the hoses, which were positioned around the emergency release tank and used to spray at the MIC and dissolve it were ineffective. The system was undersized, and did not reach the height of the gas.

was barred from management meetings," Dr Saxena recounted to Indian news site *Tehelka* in 2010.

"There was exposure to chemicals at totally unacceptable levels. There'd be a bag full of acid sitting there waiting to kill somebody."

But management was reluctant to put in place the full safety measures needed to stop accidents like gas leaks. There had been at least five chemical accidents at the plant between 1981 and 1984. A leak in December 1981 seriously injured three workers, one of who died.

Dr Saxena was there when the man, Ashraf Muhammad, passed away. He had been drenched in chemical called phosgene.

"There was exposure to chemicals at totally unacceptable levels. There'd be a bag of acid there waiting to kill somebody"

People like Kumkum Saxena feared that a disaster was imminent. Dr Saxena had been a young medical officer at the Bhopal plant, and had at first enjoyed working for Union Carbide in India. However, after a series of mishaps, she expressed worries about the safety breaches she'd observed. These were ignored, and she resigned in 1982. Leaks and near-misses caused her great concern. She'd been at the company for several years, during which time she repeatedly warned management.

"I would scream about silica dust and hydrocarbon levels. The more vocal I was, the more I was kept away. I did not get a pay raise, and soon I

"We rushed him into the shower, but it was too late," Dr Saxena said. "It's expensive to keep people safe. For a plant that wasn't making money, that was too much trouble."

At 1am on 3rd December 1984 Dr Saxena was still awake studying for a medical exam. Her phone started ringing, and on the other end were hysterical voices pleading for help.

All she could do was tell them: "Go against the wind. Put a wet cloth on your face to dissolve the gas." Dr Saxena stayed inside her hilltop home until the morning. Then she headed for the local hospital ward, missing her exam, to help the victims.

Her story was just one to be included in a dramatic BBC reconstruction of the tragedy called *One Night In Bhopal*, broadcast in 2004.

Wright said he'd never forget what he encountered. "In my sleep I still see the faces of parents whose children died. I still see children left without parents," he recounted at a 2009 Congressional subcommittee, 'Revisiting The Toxic Substance Control Act Of 1976'.

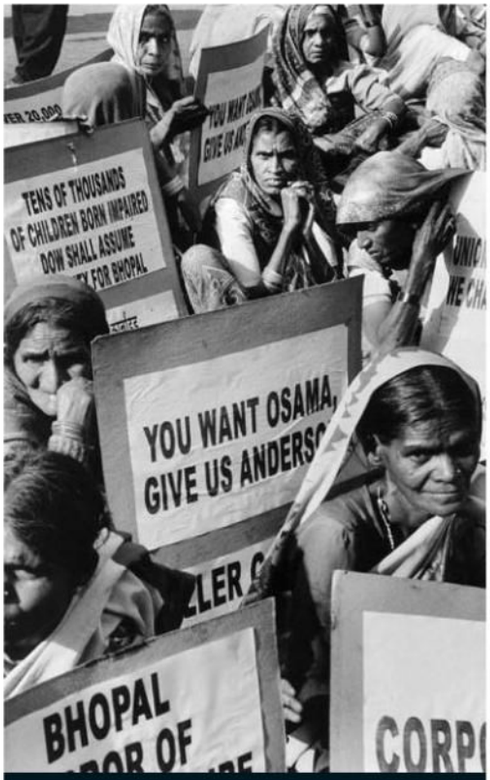
"I can still hear the constant coughing of victims who survived, but with most of their lungs burned away."

Those who survived never imagined that they'd face such a battle to get help and disastrous health consequences from the gas exposure.

Neelam Devi shared her story with Associated Press in the months after surviving the Bhopal disaster. The 32-year-old's husband died on the night of 3rd December. She was left with serious health issues, and was not able to return to her job as a maid, meaning she had no money to feed her three children.

Another survivor, 40-year-old Ashwaq Mohammad, who worked nearby as a labourer, said in 1985 that no one would employ him now his health had been so weakened by the gas exposure."My body is wasted... I look strong but I can't even lift my child."

Colin Toogood of the British-based Bhopal Medical Appeal charity, says that there were around 120,000 people in Bhopal still suffering the effects of their exposure to MIC, and would require healthcare for as long as they live.



ENEMY NUMBER ONE

Warren Anderson was the global chief executive and chairman of Union Carbide, presiding over 700 plants around the world, when disaster struck at the Bhopal plant. Anderson, then 63, travelled to Bhopal four days after the accident, where he was arrested on arrival. But after quickly paying $2,000 bail, he never returned India to face trial.

The Indian Government considered Anderson a fugitive from justice, and made several requests to the United States government for his extradition. The survivors of Bhopal, the government and Indian media never stopped calling for Anderson and the corporation to be held accountable for the tragedy.

When asked in a 1986 newspaper interview what lessons he learned from Bhopal, Anderson said: "Why not say that the Third World ought to have regulations so people are not permitted to gather around your plant in clusters? We built [Bhopal]. Put a brick wall around it. People started moving out to the plant. They used the brick wall as the only solid wall of their huts. Soon a lot of people were living around the plant, and soon the government legalised their settlement so that they could vote."

He was asked in the same interview if he should have resigned after Bhopal (he eventually did in 1986). "The way I grew up, I think resigning would have been the coward's way. To stand up there and face the public and to answer the question, that's hard. Resign? That's simple."

He died in 2014 at the age of 92, having slipped into a life of anonymity, reportedly haunted by the disaster.

When news of his death reached the media, one month after he died, newspapers in India reported there was "no redemption" for Anderson. Bhopal survivors and activists placed a large picture of Anderson outside the plant and spat at it.

"The health effects are myriad and severe, since the chemicals attack all of the body's organs," Toogood says. "There are lung problems, renal problems, sight problems, joint problems, skin problems and alarming rates of cancers. The list just goes on.

"Women are particularly badly hit, having to deal with menstrual, reproductive and endocrinal problems in a traditional society where these issues are not easily discussed."

The factory remains a toxic hazard to this day, and there are hundreds of tons of toxic waste stored in bags around the abandoned factory, along with numerous labs full of bottled chemicals, all covered in dust and cobwebs. Chemicals continue to leak and pollute the groundwater.

"But this is only a part of the problem, since toxic waste was buried in unlined pits all around the factory premises, and later pumped out to vast 'solar evaporation ponds' (SEPs) a couple of hundred metres north of the factory," explains Toogood.

"With every monsoon, rain leached through the toxic waste buried on the factory site, and later the liners of these vast SEPs began to fail."

Toogood says that this problem pre-dated the 1984 gas disaster. "A March 1982 telex, from Bhopal to Union Carbide's HQ in Danbury, Connecticut, revealed that 'Evaporation pond almost emptied... investigation of the leakage in Progress. Unfortunately, emergency pond has also shown some signs of leakage'", he reveals. "The SEPs were never repaired."

A report published in the journal *Environ Health* called 'The Bhopal Disaster And Its Aftermath: A Review' stated that industrial plants like Union Carbide's operation should never be allowed to be situated in urban areas of cities like Bhopal, where the public health infrastructure was poor.

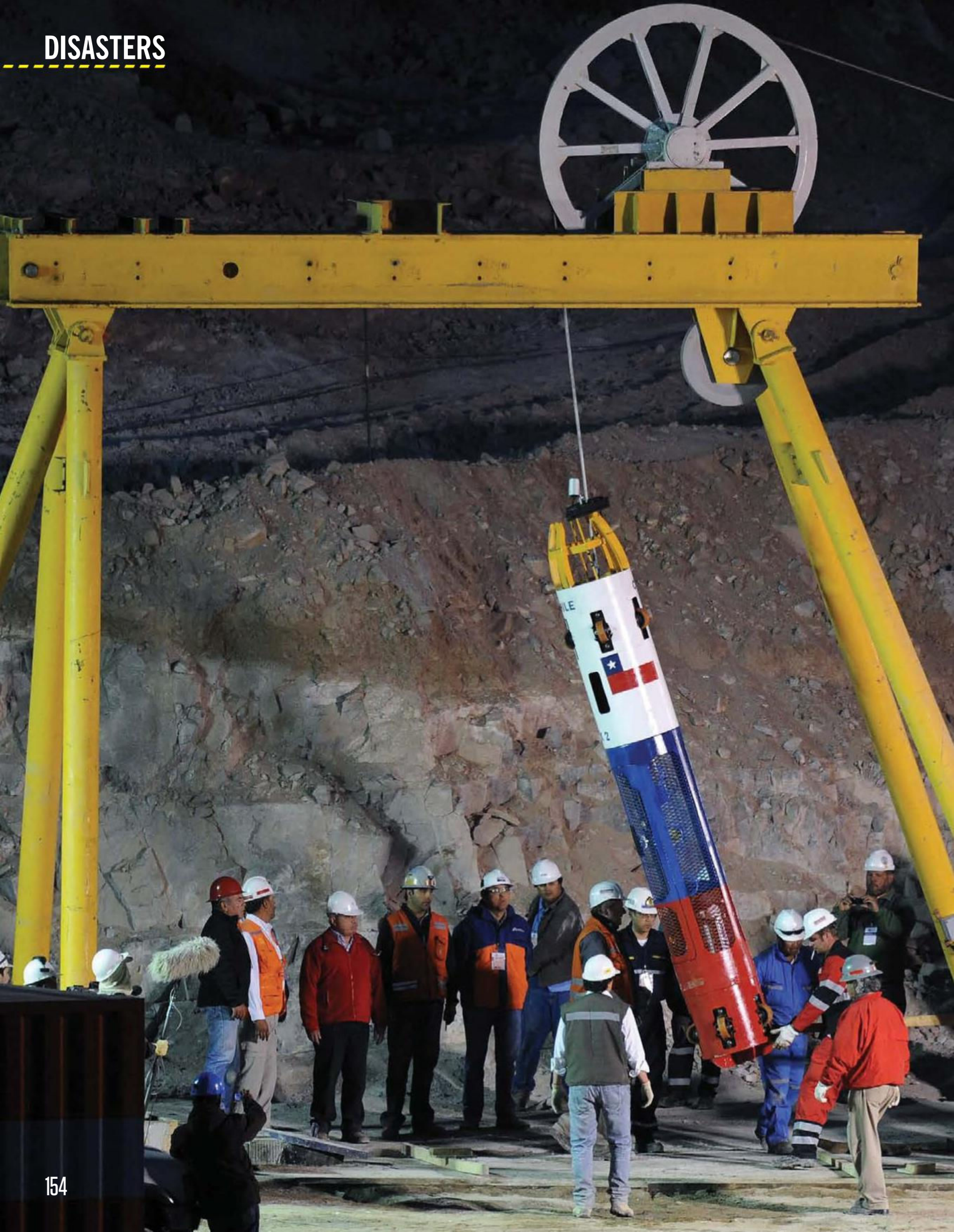
"Bhopal and its aftermath were a warning that the path to industrialisation, for developing countries in general, and India in particular, is fraught with human, environmental and economic perils," the report concluded.

The anger of the people of Bhopal has not subsided over the 31 years since the disaster. The worst affected people were also the poorest and most vulnerable – those who lived in the slums surrounding the factory site. Children born to parents exposed to the gas on that terrible night had birth defects and chronic health conditions. Furthermore, the problems of the gas exposure is now being seen in the third generation.

Over the decades, the numerous legal attempts to bring Union Carbide to justice for the disaster have been futile. Even though the Indian Government agreed to a settlement from Union Carbide for $470 million in 1989 (the company initially faced a $3 billion lawsuit), it was not enough to deal with the catastrophic consequences of the industrial disaster. It was not enough to provide critical care for all the victims.

The Bhopali hatred of the corporation, and in particular its CEO at the time, Warren Anderson, never abated. Effigies of Anderson were burned and hanged at protests over the years. When Anderson died in 2014, the people of Bhopal were enraged. In their eyes, he had escaped justice when he should have spent the rest of his life in jail, paying for Union Carbide's mistakes.

The Dow Corporation acquired Union Carbide in 2001, and refused to assume any additional liability for Bhopal, arguing that the debt had already been paid through the court settlements in previous years. Dow Chemical has been served notice on several occasions, but has consistently refused to attend any hearings.



IN BRIEF

- **Cost: $20 million**
- **San José, Chile**
- **5th August 2010**

Trapped in a refuge half a mile underground for 69 days, with no sunlight, little food and next to no water, things didn't look good for Chile's group of 33 San José miners.

THE CHILEAN MINING DISASTER

Chile's 33 miners fight for survival half a mile underground, as their saviours fight to get them out...

The word 'disaster' conjures up images of destruction and tragedy, bloodshed and often loss of life. Occasionally, however, disasters have happy endings. When San José's 121-year-old copper-gold mine collapsed, leaving 33 miners trapped in a shelter almost half a mile underground, chaos broke out. The race to rescue the miners was extraordinary; reporters showed up to spread the word, drilling experts headed to Chile and the story became worldwide news. More than eight weeks later, all 33 miners emerged from the ground and were welcomed back to the surface as heroes.

The morning of 5th August 2010 just felt like a normal day at work for the miners, who later became known as *Los 33*, or the 33. Based at the copper-gold mine in the Atacama Desert, about 45 kilometres north of Copiapó, Chile, the miners would journey down to the depths of the mine every day to extract copper and gold. But by 2pm that afternoon, their lives had changed forever. The miners didn't see the sky for 69 days.

No one suspected anything disastrous had happened at first. It was just another day at work. It wasn't until a miner named Alex Vega Salazar failed to sign in after his shift that people began to notice something was wrong. When the other 32 men also failed to sign in, their families started to worry. Alex's father José was the first to volunteer to look for them. He knew the mine well, having worked in it for many years, and gathered a search party to drive down and survey the area. When they realised that the path was blocked by a huge slab of fallen rock, all hope for his friends and colleagues seemed lost.

"The floor was cracked, the ceiling was cracked, the walls were cracked," José Vega later said. "Rocks were falling from everywhere. The truth is it was frightening." The search party's only chance of finding the missing miners was if they could find a way down the tunnel beneath the collapse. As a last resort, they attempted to abseil down through vertical ventilation shafts that linked the mine's tunnels. Unfortunately, the mine was too unstable, and a second collapse crushed the shafts and the group's chances of rescue. José and his team had no choice but to leave the mine without knowing if Alex and the other 32 men were alive or dead.

There's still no telling what caused the sudden collapse, but the mine was old, had exhibited previous evidence of geological instability and had a long record of safety violations that ended in a mixture of fines, accidents and eight deaths. As a result of the mine's shady history, many people were quick to assume that the men hadn't survived, but it didn't take long for their shock to transform into hope. The families and friends of the trapped miners, as well as much of the public who had heard about the incident from across the globe and followed its progress, immediately urged the Chilean government and San Esteban Mining Company, the cash-strapped mine owners, to knuckle down and immediately start planning a rescue mission.

It wasn't long before the area's mining minister Laurence Golborne got involved, and started looking for new ways to reach the men. With a manned rescue mission out of the question, nine high speed drilling rigs arrived at the site, and they began to drill.

On day seven of the rescue, they were still drilling. More and more of the miners' friends and families convened at the site each day, worried and desperately waiting for news. More holes were made, but each time they came up blank. Having checked the first and second levels of the mine for signs of life, the rescue team were forced to conclude that the men – if they were even alive – had taken refuge in a room at the very bottom of the mine, five kilometres from the entrance and down spiralling underground service ramps which contained enough food to feed the 33 men for just three days.

14 days after the first rescue attempt, the drills finally reached the bottom, but in a case of pure bad luck they missed the target by less than 100 feet. "It's obviously a big disappointment for the crew," said Raúl Dagnino, the man in charge of the drilling rigs. "We normally work to find minerals; we never drill to find life. You see the camp and everybody there, people crying, and it's getting critical. More days, less chances. We have to keep drilling until we hit a target."

On day 17, most had given up hope. But in the early hours of the morning, one of the rigs finally managed to break through into a tunnel very close to the refuge the rescue team were aiming at. Engineers thought they could hear faint banging sounds reverberating up the drill pipe, and so begin to winch the drill back up to the ground. Worries were instantly quashed and replaced by hope and optimism when word got out what they found. Attached to the end of the drill was a note. It read: "We are well in the refuge, all 33 of us." The following celebration from friends, family, engineers and rescue workers was almost deafening. The note was the very thing they needed to help them continue their mission. With their faith renewed, everyone eagerly cracked on, excited and joyful.

A CCTV camera and phone were lowered down the drill pipe to the refuge, and the people on the surface got their first view of the miners below. In the mine with Alex Vega Salazar (31 years old) was Ariel Ticona Yanez (29), Carlos Andres Bugueno Alfaro (27), Carlos Mamani Solis (23), Carlos Barrios Conteeras (27), Claudio Acuna Cortes (34), Carlos David Yanez Lagos (34), Daniel Esteban Herrera Campos (27), Darios Antonio Segovia Rojas (48), Edison Fernando Bena Villaroel (34), Esteban Alfonso Rojas Carrizo (44), Florencio Antonio Avalos Silva (31), Franklin Lobos Ramirez (53), Jorge Henriquez Gonzalez (54), José Ojeda Vidal (47), Juan Carlos Aguilar Gaete (49), Juan Illanes Palma (52), Jimmy Sanchez Lagues (19), Luis Alberto Urzua Iribarren (54), Matio Nicolus Gomez Heredia (63), Mario Sepulveda Espinace (40), Omar Alejandro Reygadas Rojas (56), Osman Isidro Araya (30), Pablo Amadeos Rojas Villacorta (45), Pedro Cortez Contreras (25), Raul Enriquez Bustos Ibanez (40), Renan Anselmo Avalos Silva

The rescue crew worked day and night to bring the miners back home

LET FAITH GUIDE THE WAY

Religion has always been a large part of Chilean culture. It also played a large part in the 33 retaining their spirit in the mine, even when things looked truly hopeless. Many of the men were Roman Catholic, and asked for religious items like rosaries, Bibles, crucifixes and statues of the Virgin Mary and other saints to be sent down to them through the supplies pipe. Some of the miners even set up a makeshift chapel within the confines of the refuge, and the oldest miner, Mario Gómez, gave spiritual council to his companions and led daily prayers. As a symbol of hope and faith for their rescue, Pope Benedict XVI sent each miner a rosary, which was delivered in person by the Archbishop of Santiago.

Since the rescue, representatives of the Chilean government, as well as the Chilean public, have credited at least part of the successful rescue attempt to Divine Providence, and viewed it as a miracle of sorts. Before the miners were finally back on the surface, Chile's president Sebastián Piñera confirmed his faith in their safe return, saying: "When the first miner emerges safe and sound, I hope all the bells of all the churches of Chile ring out forcefully, with joy and hope. Faith has moved mountains."

THE PROBLEM WITH MINING

Chile's long tradition of mining has led the country to becoming the world's top producer of copper. Its workers also are some of the highest-paid miners in South America. According to figures from the National Geology and Mining Service, an average of 34 people per year have died in mining accidents since 2000, with a high of 43 in 2008.

Although no one ended up being charged after the Copiapó mining incident and the cave-in was ruled as an unfortunate accident, problems had been following the San José copper-gold mine for years. Its owner, the San Esteban Mining Company, also known as CMSE (Compañía Minera San Esteban), became pretty notorious in the industry for operating unsafe mines. An official for the non-for-profit Chilean Safety Association even claimed that eight people had died in mining-related accidents at the San José site over the past 12 years, while CMSE was fined 42 separate times for breaching safety regulations between 2004 and 2010.

The mine was temporarily shut down in 2007 when the relatives of a miner that was killed in a freak accident sued the San Esteban Mining Company. However, it reopened in 2008 and resumed business as normal, despite non-compliance with regulations. After that, money was tight, and due to budget constraints for the region, there were only three health and safety inspectors working on all 884 of the area's mines.

The CMSE built up a reputation for not only having unsafe working conditions but also basically ignoring the complaints and queries of its employees. Many people believe that if the San José mine's owners had just taken more notice of the miners themselves then the 2010 Copiapó mining accident could have been avoided completely.

"A CCTV camera and phone were lowered to the refuge, and the people on the surface got their first view of the miners below"

(29), Richard Reinald Villarroel Godoy (27), Samual Dionisio Avalos Acuna (43), Victor Antonio Segovia Rojas (48), Victor Zamora Bugueno (33) and Yonni Barrios Rojas (50).

The first to properly communicate with the outside world was Luis Urzua. Luis was the shift foreman when the mine collapsed, and ended up showing just how worthy he was of the job. He managed to keep a cool head and encourage the men to stay positive and united. "You just have to speak the truth and believe in democracy," he later told *The Guardian* from his hospital bed at the mine site. "Everything was voted on... We were 33 men, so 16 plus one was a majority."

In the 17 days before first contact was made, the atmosphere in the mine was very bleak. No one knew if rescue was on the way, or if they would be able to hold out much longer. The men quickly became extremely malnourished, surviving on a handful of tuna and a few sips of milk each every 24 hours. After the rescue, some of the men admitted they were all just waiting for death. One explained how they had attempted to open a line of communication with the surface, setting fire to oil filters and tires and using them as smoke signals by placing them in the ventilation shafts. Petty squabbles broke out very easily and hopelessness soon set in. But even worse was the constant nagging, but unspoken, fear that sooner or later, if help didn't arrive, they might have turned to cannibalism.

After everything that had happened, that first phone call from the mine to the ground became the light at the end of a long, dark tunnel. The first words spoken from the depths of the mine were from Luis Arzua. "Yes, I can hear you!" he said. The people gathered on the surface exploded with joy. "We're fine! We're waiting to be rescued!" Laurence Golborne, the mining minister, wasted no time in giving him the good news. "We are starting work on digging tunnels and chimneys," he said. From the phone line came the best response they could have asked for: the 33 men started clapping and cheering, and broken into the chorus of the Chilean National Anthem. Things were finally starting to look up.

The joy at finally being found was overwhelming. It was a good while before anyone

THE RESCUE BEGINS

PLAN A

The first attempt at a rescue came in the form of a Strata 950 model raise borer. Built in Australia and provided by South African mining company Murray & Roberts, the drilling rig was used to create circular shafts between different levels of the mine without the use of explosives. The Strata 950 weighed 31 tons and had to be shipped to San José in pieces on a truck convoy. Rescuers had to abandon Plan A as further drilling would cause the escape shaft to crumble, and meant the miners would have had to remove several tons of debris.

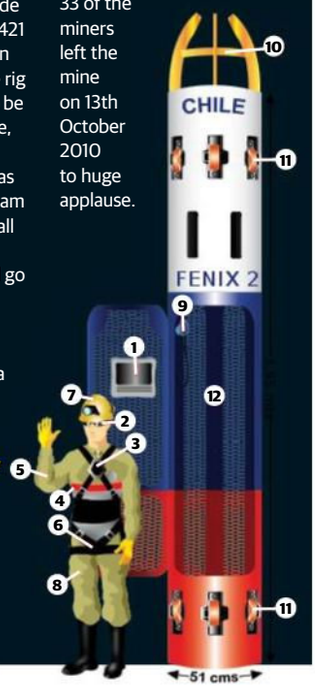
PLAN B

Plan B required a Schramm Inc T130XD air core drill. It used four hammers working together to widen one of the three narrow holes that were already in place to send food, supplies and supplements down. The drill was also the first to reach the trapped miners. Using percussion-technology, the drill was able to chip away more than 40 metres of rock per day, and widen the 14-cm hole to 30 cm. However, the holes then needed to be expanded to 71 cm in diameter, but doing so would have put too much pressure on the drill bits.

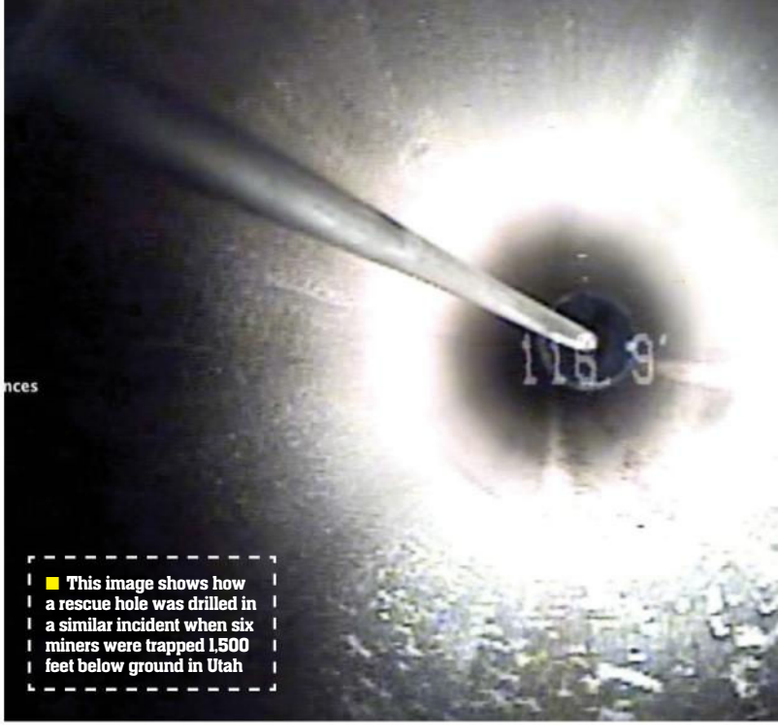
PLAN C

The miners' last hope was a powerful Canadian-made oil drilling rig called RIG-421 operated by the Precision Drilling Corporation. The rig was massive, and had to be transported from Iquique, Chile, to Copiapó in 40 truckloads. Because it was so big, and the rescue team was aiming at such a small target, there was every chance that things could go horribly wrong.

Once the hole was finally wide enough, the rescue team sent down a capsule (referred to as the Phoenix) using a winch and pulley system, and started to haul up the miners. Each wore a bio-harness designed for astronauts to monitor their heart rate, temperature, breathing and oxygen consumption, as well as sunglasses, to protect their eyes from the outdoor glare after experiencing so many days of darkness. It took almost 24 hours to complete the rescue mission, but one by one all 33 of the miners left the mine on 13th October 2010 to huge applause.



1. Monitor for biometric belt
2. Special dark sunglasses
3. Safety harness with five hooks
4. Biometric belt
5. Water resistant, sweat permeable, coveralls
6. Copper fibre underwear to minimise fungus
7. Helmet adapted for communications
8. Wraps to prevent thrombosis
9. Oxygen mask
10. Connection to the winching system
11. Stabilisation wheels
12. Rescue capsule



This image shows how a rescue hole was drilled in a similar incident when six miners were trapped 1,500 feet below ground in Utah

First contact with the trapped miners via video was made after 17 days

managed to come back down from that high. The first port of call for the rescue workers was getting the men some adequate sustenance, and they really went all out; to ensure the food didn't cause a fatal shock to their systems, the Chilean government called up experts from NASA for advice. Dr James D Polk, the organisation's then-deputy chief medical officer, said: "Because the miners were eating barely enough to get by, probably less than 300 calories a day, in effect they were starving. What we worry about is something called re-feeding syndrome, which can cause a low level of phosphate, which can then lead to cardio arrhythmias or cardiac failure." To remedy this, a mixture of glucose, vitamins and minerals were shipped down through the hollow tubes.

Several cameras followed the food to the refuge so the men could film messages to their families and tell their stories. Most of the messages were hopeful and uplifting. They filmed tours of their shelter, and the accessible tunnels around it, and told of how they attempted to cook soup shortly after they were first trapped. Luis Urzua spoke of how he couldn't wait for the minute he would be together again with all his family.

However, things weren't always rosy. The miners were perhaps only keeping up appearances for the cameras in an attempt to make their families believe they were healthy and happy. Victor Segovia, who worked in the mine as an electrician, revealed the real truth in a letter sent up to his brother. "There's no way I'm going to lie to you [about] how things are down here," the letter said. "It's very hard. This hell is killing me. I try to be strong but it's difficult. Sometimes when I sleep, I dream I'm at a barbecue. When I wake up I find myself a prisoner in this darkness that wears you down day by day."

By day 19, the mine site started being referred to as Camp Hope. With the miners no longer starving, the next step was to start drilling a hole big enough to get them out. The plan involved sending a man-sized capsule down the shoot and manually pulling the 33 back up to the surface one by one. But in the meantime, they also needed to focus on their health. Without the presence of UV light, the men were more at risk to bacterial and fungal infections. A few already had pre-existing conditions, like diabetes and high blood pressure. With the men already weak from lack of nutrients, something as simple as an infection could be fatal.

Adding insult to injury, the conditions of the refuge were also abysmal. For the weeks they were down there, the miners were living in a constant temperature of 35 degrees Celsius, and the humidity in the air was a suffocating 95 per cent. To keep them relatively happy, the rescue workers up at Camp Hope started taking requests from the miners while the engineers continued to drill. The first request was for cigarettes and alcohol. Unfortunately for the miners, their rescuers decided that wasn't such a good idea for people trapped in an underground shelter

FACTS

33 miners were trapped underground and all survived

TRAPPED **2,300** feet underground

22½ hours it took to pull up all 33 miners

69 days The men survived underground

IT TOOK **28** days for the miners to receive a hot meal

The miners' ages ranged from **19** to **63**

■ The miners were able to send a message reading: "We are fine in the refuge – The 33"

with limited space and little to no ventilation, and sent down nicotine patches instead. But as a consolation prize, they received a surprise delivery of a projector and half a mile of fibre optic cable, and the miners got to watch a live football match between Chile and Ukraine, while their families watched in a tent at Camp Hope. For a short while, the refuge was filled with clapping and jovial chanting. Strangely, one of the miners, Franklin Lobos, was a retired professional football player and provided the half-time analysis, but the match ended in a 2-1 defeat, bringing down the mood.

Back at Camp Hope, the rescue seemed like a done deal as they approached day 24. But things suddenly took a turn for the worse when it was discovered something was obstructing the one of the drill rigs. After sending a camera down, the rescue workers soon found that the hammerhead had disintegrated, the cause an iron roof bolt of a tunnel no one knew existed. On day 36, another of the rigs had to be shut down owing to a leaking hydraulic hose. The miners had noticed the drilling stopped, and began to get even more restless.

The two drills, known as Plan A and Plan B, might have been out of action, but all hope wasn't lost. Finally, on day 37, Plan C was shipped in. At 150-feet-tall, the new drill rig offered optimism where there previously was none. Eventually, all three drills were back on line, leaving the engineers free to make that final push. After weeks of work widening the hole to make it big enough for the escape capsule to pass through, and several technical problems, the mission was almost over.

On the morning of 13th October, the capsule was finally sent down to the bottom of the mine, and a plan was set in action. The journey back up would take 20 minutes and the capsule was narrow and claustrophobic, but it had an oxygen tank and a harness. The stronger men would ride first, just in case there were any problems, and the ill and elderly would ride second.

Finally, after 69 days of soul-crushing darkness, the miners were winched back up to the surface. The inspirational event was televised and watched by more than a billion people all over the world. Like a captain staying with his ship, shift foreman Luis Urzua was the last to leave the mine. Upon stepping out of the capsule, he was greeted with balloons, confetti, and thunderous applause. He was welcomed back a hero.

After their rescue, the miners became international stars. Even though they had been watching events unfold on the news, everyone wanted to hear their stories first hand, with outlets offering up to $250,000 each for a world exclusive. The 33's incredible journey just goes to show that when things do go wrong, there are always dedicated helpers ready to make things right again.

WHAT HAPPENED NEXT

A lot has happened between the miners' rescue and now, some good and some not so good. Seeing as their story made worldwide news, The 33 found themselves in the limelight for some time afterwards and they decided to use that blessing to help others. Together, they set up a foundation which would let the share their experience while also urging people to improve mine safety so that it wouldn't happen again.

But the newly-formed foundation wasn't the only charitable act that came out of the disaster; in the summer of 2011, Chilean first lady Cecilia Morel presented 14 of the 33 miners with lifelong pensions on behalf of President Sebastián Piñera. "When the accident happened, we put all of the resources available to us to rescue you," said Morel. "We accompanied your families every moment and we could not abandon you to fate afterwards. This government is committed to be with you and help you as much as we can." Each of the 14 will receive a monthly pension of 250,000 Chilean pesos (about £285) for the rest of their lives.

The bad comes in the form of placing blame for the accident. Understandably, the families of the miners filed a lawsuit against the San Esteban Mining Company, while the judge froze US$2 million of San Esteban's assets. On 1st August 2013, after a three-year investigation, the investigation surrounding the mine's collapse came to a close, and now charges were filed.

Interest in the miners may have died down after their stories were released and retold but it never disappeared. In 2014, director Patricia Riggen started work on a film called *The 33*, which told the story of the disaster and what went on in the mine. It was released in November 2015, and starred Antonio Banderas, Rodrigo Santoro, Juliette Binoche and Josh Brolin. However, the film received mixed reviews, with some critics applauding the inspirational account of heroism and others criticising the fact that it felt like an all-out disaster movie rather than a sober, fact-based biopic.

IN BRIEF

- **Death toll: 722**
- **Central Luzon, Philippines**
- **15th June 1991**

Following a series of small earthquakes, Mount Pinatubo erupted just as a terrifying typhoon hit town. Were it not for the intelligence gathered by scientists, the death toll could have been catastrophic.

MOUNT PINATUBO ERUPTS

Mount Pinatubo blew its top just as a typhoon struck. But how did scientists help save thousands of lives?

The US team members were gnawing at their fingernails, nervously pacing around their office and reaching for coffee to help make themselves feel more alert. It was the evening of 10th June 1991 and they had made a monumental decision that day over an issue which had seen them clash numerous times with the US military.

The anxiety among the group from the United States Geologic Survey's (USGS) Volcano Disaster Assistance Program was centred on Mount Pinatubo, and their prediction that it was about to blow. Yet they could not say for certain that anything was going to happen. All they knew is that they desperately needed this volcano to erupt.

Mount Pinatubo lies on the island of Luzon in the Philippines and it is just 90 kilometres northwest of the capital Manila. It's in the midst of the jungle-covered Zambales mountain range and, until 1991, it had lain dormant for a little under 500 years. For the half a million people who lived within 40 kilometres, it was simply a piece of natural background furniture that in most cases had gone completely unnoticed. It had never in their lifetime posed any danger and few people had even heard yet alone seen it. But that was about to change. On 15th March, the Philippine Institute of Volcanology and Seismology (PIVS) had noticed a series of earthquakes and it was becoming apparent that Mount Pinatubo was awakening.

By 2nd April, the problem was clear. A crack of about 1.5km in length had opened across the north side of the existing lava dome. At the request of the PIVS and following a subsequent number of steam explosions, a team of three people from the USGS was despatched to the Philippines to help monitor the volcano around the clock. When they witnessed a succession of explosions, a second group, which numbered volcanologist and college graduate John Ewert, was also sent out. They rolled up their sleeves and got down to business.

"At that time, it was not widely known that Pinatubo was an active volcano," says Ewert. "It was a subtle feature in the jungle rather than the large, cone-shaped volcano that people are familiar with. So we went into it cold. There had been no seismic instruments near it prior to the activity on 2nd April and we were working from scratch. We didn't know much about what we were dealing with other than it had never erupted in anyone's memory."

After 2nd April, the Philippine volcanologists had placed portable seismic recorders to the northwest of the volcano and, five days later, anyone within ten kilometres of the volcano's summit was asked to leave. When the USGS team arrived, they added radio telemetred instruments into the mix. But even though the focus was on the volcano itself, they were very much concerned about their surroundings. For not only was the volcano close to the city of Angeles with its hundreds of thousands of residents, it was also in between two of the largest US foreign military bases at the time: the Subic Naval Base and the Clark Air Base.

Clark was home to a permanent population of 15,000 people and the economy of Angeles was heavily dependent on it, but it was also very sensitive. As the team began to draft evacuation plans, they had to negotiate the politics of disaster management. It was a twin battle in some respects, but one that they knew they had to get right.

"Our goal was to figure out what hazards this volcano would present to the Philippines and the

Volcanologists Maurice and Katia Krafft

CASE FOR EVACUATION

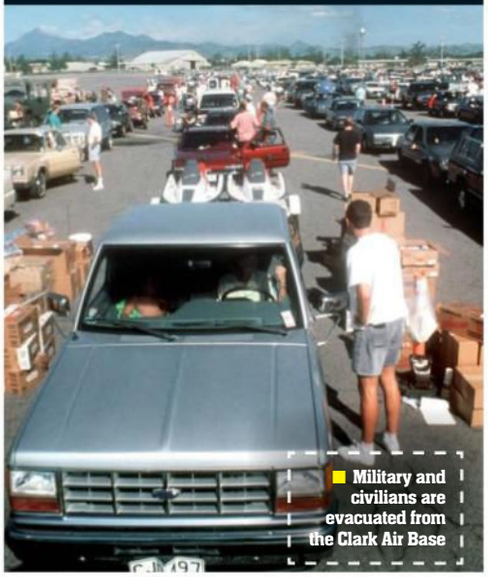
Persuading people to evacuate isn't easy but for Mount Pinatubo, the experts were helped by two other disasters. The first was the eruption of Nevado del Ruiz in northern Columbia in 1985 which caused a mudslide and killed 23,000 people.

"That catastrophe was a result of poor communication among scientists, the authorities and the public and, as a result of that, the volcanological community resolved to improve the way scientists communicated with the decision makers," says volcanologist John Ewert.

The second involved husband and wife volcanologists and vieographers, Maurice and Katia Krafft, who were commissioned by the International Association of Volcanology to create instructive videos of volcanic phenomena and its impact on people and agriculture. Their first task was to look at the aftermath of Columbia.

The Kraftts produced a video called Understanding Volcano Hazards and a rough cut of this was used by the USGS team in the Philippines to make their case about Mount Pinatubo. But on 3rd June, the Krafts were filming the eruption of Mount Unzen in Japan and they were were among 41 people killed by a pyroclastic flow.

"This had a big impact on our scientific team and on the people we were trying to convince," says Ewert. "We would say, look, here is the video of Nevado del Ruiz but understand the people who produced it died in a pyroclastic flow just a few days ago. You need to take this seriously."



Military and civilians are evacuated from the Clark Air Base

US military bases," says Ewert, who is now a top scientist in charge of the USGS' Cascades Volcano Observatory in Vancouver. "We were seeing if we could forecast when an eruption may occur but the bases were a source of much stress and anxiety on the part of the scientists. There was a concern that if they were evacuated then it would be tantamount to abandoning it and that is not something the military establishment or the diplomatic community wanted to see happen at that point."

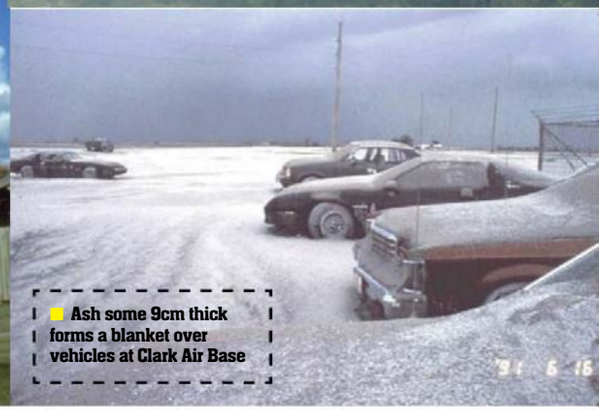
To gain a more accurate estimate, Ewert's task was to supplement the seismic monitors with tilt meters - "they are essentially an electronic carpenter's level but one that is extremely sensitive," he says - and these were used to detect the inflation of the volcano as the magma reservoir beneath the volcano grew or as the conduit opened towards the surface. As the days went by their concerns became more acute. By the first magmatic eruptions on 3rd June, they knew plans would have to be acted upon sooner rather than later.

Indeed, within four days, a large explosion produced an ash column that soared seven kilometres into the sky. It was time to persuade people that they may have to leave or else perish in the oncoming onslaught.

Talks continued between the scientists, elected officials and the public. Meanwhile, the team looked at past deposits from the volcano as they tried to piece together clues and figure what would happen. As plumes of ash continued to filter into the air, it was time to take action. Anyone within 20 kilometres was told to evacuate.

Soon, though, it was the turn of the service members and families living at Clark Air Base to evacuate. After some persuasion, this took place on the morning of 10th June. Around 14,000 people walked across the fields with their bags in hand to awaiting buses that were driven in to help the evacuation. As expected, it was orderly and calm but there was still resistance elsewhere. "The mayor of Angeles decided the Americans were Chicken Littles saying the sky was falling in," says Ewert. "He said there was no reason to be concerned and that everyone should go about their business as usual. He was not re-elected." It became obvious why.

"Around 14,000 people walked across the fields with their bags in hand"



Ash some 9cm thick forms a blanket over vehicles at Clark Air Base

AFTERMATH OF A VOLCANO

In the aftermath of the eruption, the landscape was transformed. "It became very grey, very monotone and it had a little bit of an acrid sulphurous smell," describes volcanologist and witness John Ewert. The effects of the volcano and the typhoon had also taken their toll on the ground.

"When you put five, six or seven cubic kilometres of fragmental material on a highland area and you get a typhoon with many centimetres of rain, you generate debris flows," explains Ewert. "Since water does not infiltrate as it would in normal soil – because the ash is water repellent, or hydrophobic – the rain gathered loose fragmental material with it. It bulked up as it flowed downhill so you got these flows that have the consistency of flowing concrete. It was very dense and in the case of Pinatubo it was very hot because they were coming off of pyroclastic flow deposits that have just been laid down.

"So you got this incandescent hot material at 400 or 500 degrees Celsius, added with water, running downhill. It created problems for the next ten years for the three provinces around Pinatubo."

The aftermath was also uncomfortable for the survivors. "It was hot and humid," Ewert says. "If you imagine being in 32 or 33 degrees Celsius with talcum powder-sized dust on you all the time, you can imagine how much of an uncomfortable environment it was. The grit sticks to everything. It took four days to get the ash out of my hair and off my body."

On 12th June at 8.51am, a Vesuvian eruption which lasted up to 20 minutes created an ash cloud 19 kilometres high. "It was very impressive," says Ewert admiringly. "It made a large umbrella cloud and it was so beautiful and clear that everyone could see it." Ewert was relieved. "People could now understand that this is a big thing which is happening here." A super-massive pyroclastic flow extended four kilometres from the summit but it was only just getting going. "We were really fortunate to have these initial explosions in daylight hours when people could see them," says Ewert, who says it helped with the subsequent evacuations. "We'd only evacuated 48 hours earlier and although we were tired and stressed, we were fortunate that our forecast had been borne out."

Three days later, Pinatubo unleashed its biggest fury. The eruption cloud reached 34km into the sky and the umbrella spanned 400km. The noise of the debris smashing together was almost deafening. "The volcano behaved in a manner that didn't pull any tricks so there was an element of luck there and at certain times luck works in your favour," says Ewert, who was in the thick of it.

Yet no-one counted on the cyclone Typhoon Yunya throwing a spanner in the works as it moved west to northeast at the same time the volcano was at its peak. Winds howled at up to 195kph, striking southern Luzon on 15th June. The rain smashed the earth, causing flash floods and sweeping away homes. It was mixing with the volcanic ash and making a bad situation terribly worse.

"If someone would have told me that I was going to be present at one of the largest eruptions of the 20th century and, by the way, on the same day there was going to be a typhoon coming ashore and tracking across the volcano, I would have said, 'no, the odds of that are vanishingly small and that is not something I can plan for,' and yet there you have it," says Ewert. "It happened."

As ash fell on to the rooves of houses and the rain pounded down, the water combined to create a heavy mass on structures not built to support such a load. The buildings collapsed under the weight, killing hundreds. "The earthquakes as the caldera was forming had shaken the structures so with the load and the wind, the houses couldn't stand," says Ewert. "That is where, by and large, most of the casualties occurred on 15th June. People were sheltering and saw structures collapse on them."

The team's instruments were destroyed too and danger was very much upon them as they completed their last of observations at their offices in Clark Air Base. It was time for them to join the 250,000 people on the move. "We evacuated Clark Air Base at 2pm, leaving behind the only remaining instrument still operating." It was a good move, since the base suffered such extensive damage that it eventually had to be abandoned for good; the Philippine government unable to reach new terms on the lease of such a battered area.

When the dust settled there was good news and bad. The death toll was around 800 and more than 10,000 people had been left homeless. But, it was estimated 20,000 lives may have been saved due to the early-warning actions of the scientists.

THE HINDENBURG DISASTER

When the Hindenburg airship came down in flames, spilling burning bodies from its carcass, it foretold a larger disaster – world war

Herb Morrison, a radio announcer, was waiting at Lakehurst in New Jersey for the arrival of the world's largest airship to land, after its three-day journey from Germany across the Atlantic. He was recording a piece that was intended to give his listeners, later that day, a joyful account of the airship's safe arrival – a major feat and one that would confirm a new age of international travel. As he looked on, the crowds around him cheered; but then, suddenly, the cheers began to turn to cries of horror. What listeners heard, when Herb's report was broadcast later on, was an emotional outburst – including one particularly shocking, line: "Oh, the humanity, and all the passengers screaming around here!"– as the airship exploded.

A disaster that was waiting to happen, on 6th May 1937, the airship Hindenburg had exploded shortly after flying without major incident across the Atlantic, and it was just the latest – and last – accident involving this futuristic and luxurious form of travel. The Hindenburg was a symbol of Nazi power as the world moved inexorably towards total war; it stood for technological advance, for the future, for strength. Yet it had exploded. Was this a portent of things to come?

Press and public were stunned, and confused. Initially, rumours and half-truths were reported. "Last night it was reported that 32 persons had lost their lives in the disaster," the Burnley Express breathlessly noted in its edition of 8th May 1937. One Irish paper reported the US Navy Department in listing 48 deaths, but then added that officials were "still unable to give the exact death toll". The final figure, however, was 36.

There had been 97 people on board the Hindenburg when it made its last journey across the Atlantic – 36 passengers and a crew of 61. The previous year it had safely made ten round trips between Germany and America, carrying a total of over 1,000 passengers; it was not full on this trip, as it had the capacity to carry up to 50 passengers in addition to the crew. The journey was due to be the first of ten American flights that year. It started on 3rd May 1937, when the airship set off from Frankfurt at around 7.16pm. The airship flew without incident over Germany, the Netherlands and southern England, before it headed out over the Atlantic early the next morning. It had originally been due to arrive in New Jersey at 6am on 6th May, but headwinds slowed its progress. By midday it had just reached Boston, on the east coast, and three hours later it flew over Manhattan. It was at 4.15pm that it could be spotted over Lakehurst's Naval Air Station, but poor weather conditions meant that the landing was aborted, and the ship flew over the New Jersey coast for around two hours before visibility improved. At 7.00pm, at a height of 600 feet, the airship approached the landing field. It turned left to descend, and the crew reduced the ship's buoyancy in preparation. But the ship could not be kept level, with extra crew having to be drafted to add weight to the Hindenburg's bow. The wind was shifting, the weather looked like it might get worse again, and anxieties arose that the Hindenburg needed to reach its mooring mast quickly. The captain made a sharp turn in order to land into the wind, and as the ship lowered to 180 feet above the ground, its landing ropes were dropped. At 7.25pm, witnesses started to see flames emanate from the top of the hull and from between a rear engine and a fin on the left-hand side of the ship. Passengers could also see flames through their windows, as the fabric of the ship started to catch fire.

IN BRIEF

- **Death toll: 36**
- **New Jersey, USA**
- **6th May 1937**

It was supposed to be a truly modern, safe, fast form of international transport – but the puzzling explosion of the Hindenburg put an end to travel by airship.

As the ship's tail turned into a ball of flame, the Hindenburg pitched – tail up, nose down – with passengers and crew falling over, and crashing into furniture. Some were crushed by other people falling into them; others started to jump out of windows. One woman, Mathilde Doehner, managed to throw two of her children – sons Walter and Werner – out of a window, and then jumped out herself, breaking her pelvis in three places as she landed. Those who were near the windows were lucky, but for those who were in their cabins, located in the centre of the decks, they had far lower odds of escaping. Crew members in the engine and control cars had a better chance of surviving than those electricians working in the power room, as they were nearer exits. Some passengers who could have escaped chose instead to head deeper within the airship to find relatives, and so died. Others, such as Emma Pannes, ran back to her cabin to find her coat, and then found that she could no longer escape. Her husband, John, then tried to find her, and also died.

Some 30 seconds after the flames were first spotted, the airship crashed to the ground, with its hull soon being reduced to ash. The flames had almost completely disintegrated the technological marvel. In total, 35 people on board the airship – passengers and crew – died, together with one member of the ground crew. Others were taken to hospital, severely burned or injured. Mathilde Doehner's 14-year-old daughter, Irene, was so badly burned that her mother was not allowed to see her. Irene died hours after the airship crashed. One of the fatalities was the German airship commander, Captain Ernst Lehmann, who was initially taken to hospital but who died of his 'terrible injuries' there. The hospital staff noted his fortitude, stating "he never once complained, despite the horrible burns he had received". His widow, Frau Lehmann, flew from Berlin to Cherbourg, before then getting a liner across to the States to be at her husband's bedside. By the time she reached France, though, he had already died.

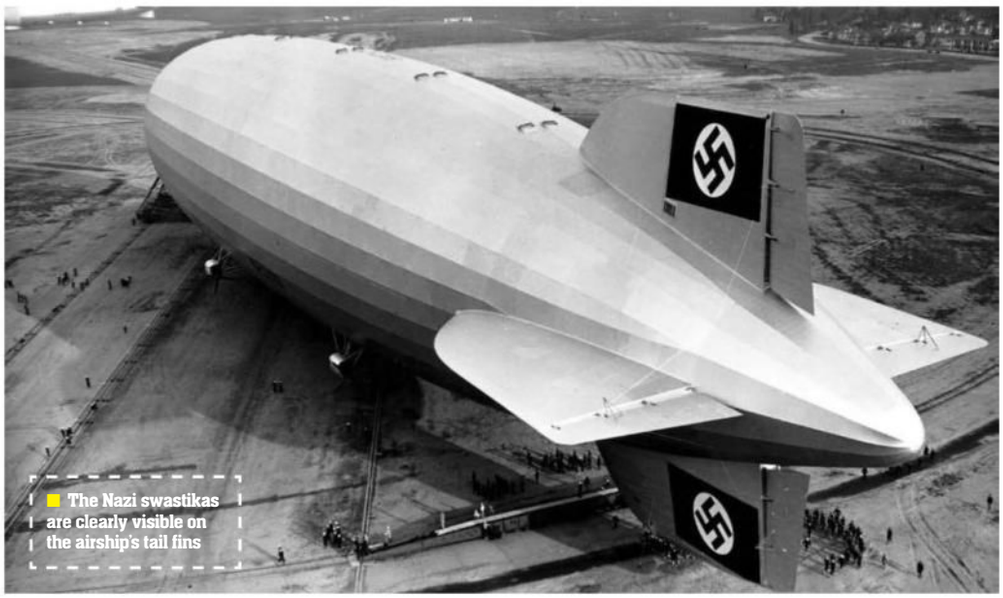
There was only one British passenger – George Grant, a steamship agent from south-west London, was a survivor, taken to hospital with a broken leg and serious bruises. He had left England for Germany the previous Saturday, having aimed to make a double flight across the Atlantic – it had been his first trip in an airship.

At 4am on the morning after the disaster, the airship was still on fire, with the flames being fed by fuel oil from the airship's diesel engines. The cause was still unknown, but 'immediate steps' had been taken to inform both Hitler and Goebbels about what had happened.

A mass funeral service was held for the confirmed victims of the Hindenburg disaster on Tuesday 11th May. The service took place on the pier of the Hamburg-America line in New York; coffins covered with flags and flowers were placed on the pier, before being taken aboard the German line Hamburg. The liner then travelled with its sad cargo to Germany. It was reported that 10,000 mourners attended the service.

The Hindenburg had always gotten attention. It was huge and looked like a spaceship, hovering above the ground. And although it was seen as an instrument of Nazi propaganda, enabling the German party to be seen as powerful and advanced, it also caused Hitler some jealousy. When it appeared above the Olympic stadium in 1936, the crowds were more occupied by it than their chancellor, Hitler, who was so annoyed that he shouted, "Hindenburg away!" to remove the object of the people's attention and divert it back to him.

Those who had developed the zeppelin were also sidelined by the Nazis. Dr Hugo Eckener, an ace flying captain and responsible for the production



■ The Nazi swastikas are clearly visible on the airship's tail fins

THE CAPTAIN'S STORY

The Hindenburg's captain, on the day of its fateful, and fatal, explosion, was Captain Max Pruss, who for the rest of his life believed the disaster had been caused by an act of sabotage.

Pruss was a 46-year-old Nazi Party member who had worked his way up to the prestigious role of zeppelin commander. He had joined the navy in 1906, aged 15, and served on various navy zeppelins during the First World War. During this time, he worked under Hugo Eckener, who would go on to design the Hindenburg. He served on the Graf Zeppelin from 1929, and became its commander in 1934. In 1936, he worked as a watch officer on the Hindenburg, under Eckener and Ernst Lehmann, before becoming its commander. He captained the airship on its flight from New Jersey to Frankfurt in 1936, and was on it for three South American crossings.

On that fateful day in May 1936, when it became clear that the Hindenburg was alight, Ernst Lehmann shouted "Everybody out!" and the crew members leapt through a window on the starboard side of the airship. Although Pruss landed safely on the ground, he went back to the burning wreckage several times to try and rescue others. He only stopped when he was physically restrained by others, and taken to the hospital. Although he survived the *Hindenburg* fire, his rescue attempts had left him with serious burns to his face and body, particularly to his upper body and arms. He was initially given such a narrow chance of survival that the last rites were read to him at hospital in Lakehurst. He was then taken to the Columbia Presbyterian Hospital in New York, which had a specialist burns unit. He stayed there for four months, undergoing many operations. However, he remained badly scarred from his burns, and had to have a prosthetic nose fitted.

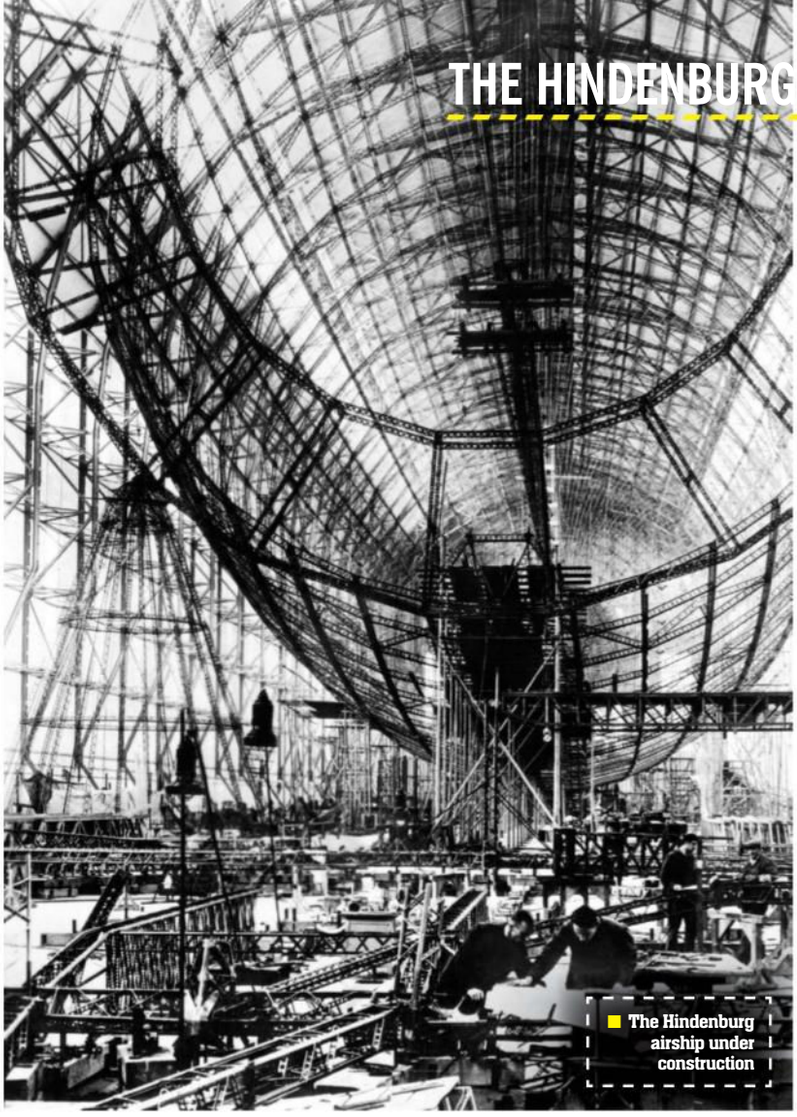
Pruss remained a fan of the zeppelin, and in the 1950s, unsuccessfully tried to get support for the construction of helium-inflated airships. He died of pneumonia in Germany in 1960.

LASTING EFFECT

The disaster was made worse because it was captured on film, in pictures and, in Herbert 'Herb' Morrison's radio recording, sound. Photographs were published around the world, showing the flames leaping from the airship, and, later, its burnt out skeleton. Public awareness of the perils of air travel, and the dangers of hydrogen, rocketed, and their enthusiasm for travelling on an airship correspondingly dived. Although airships had been used since before World War 1, their future was doomed after the Lakehurst explosion. A similar situation was seen in the 21st century; when Concorde crashed near Paris on 25th July 2000, killing all on board, it resulted in the scrapping of this similarly aspirational form of transport. As with the Hindenburg, many on board the doomed Concorde flight were German, and they were similarly on a flight heading across the Atlantic to the United States. Both the zeppelins and Concorde were aircrafts with a 30-odd year history; they were seen as the most modern form of transport, but they were soon consigned to transport's rubbish bin.

of the rigid airship Graf Zeppelin, was seen as a national hero in Germany, but had made clear his dislike of the Nazis. He had even intended to stand against Hitler in the 1932 presidential elections. Although Hitler could not afford to lose his expertise, he had him work alongside more obedient members of the party – who saw safety as a less important issue than Eckener, who was meticulous about this aspect of airship production and flight. The desire of the Nazi bigwigs to exploit the propaganda potential of the Hindenburg also resulted in shortcuts being taken. When the Hindenburg was being used for publicity purposes in 1936, a gust of wind as it was being brought out of its hangar resulted in damage to a fin. Eckener ended up arguing with Captain Ernst Lehmann as to what to do. Lehmann thought a quick repair should be made in order for its intended flight to be made. Eckener was furious, shouting at his colleague that he was risking the ship and the safety of those on board for an 'idiotic' flight. Goebbels later banned the mentioning of either man's name in association with the Hindenburg. The airship had been named by Eckener after Paul von Hindenburg, president of Germany until 1934, and opponent of Hitler; Goebbels later tried not to refer to the airship by its name, reluctant for anyone to take credit for its development apart from Hitler and the party itself.

From an early stage, there were rumblings about something untoward having happened. New Jersey's aviation director, Gill Robb Wilson, was quoted as saying, "There was something very strange about the explosion." Dr Eckener, when questioned about the possibility of sabotage, simply shrugged his shoulders, before saying, "I can regard it only as a theoretical possibility". He was not an impartial commentator, however, given his history with Goebbels and the Nazis. Colonel J Monroe Johnson,



The Hindenburg airship under construction

FACTS

Death toll: 36
earlier newspaper reports had different estimates

1 the number of ground crew who died

62 survivors. The majority of passengers survived

8 years old. The youngest passenger, Werner Doehner. He survived

Youngest crew member: 14 Werner Franz. He survived and died in **2014**, aged **92**

1 Animal fatality
German Shepherd Ulla died; her owner survived

"The desire of the Nazi bigwigs to exploit the propaganda potential of the Hindenburg also resulted in shortcuts being taken"

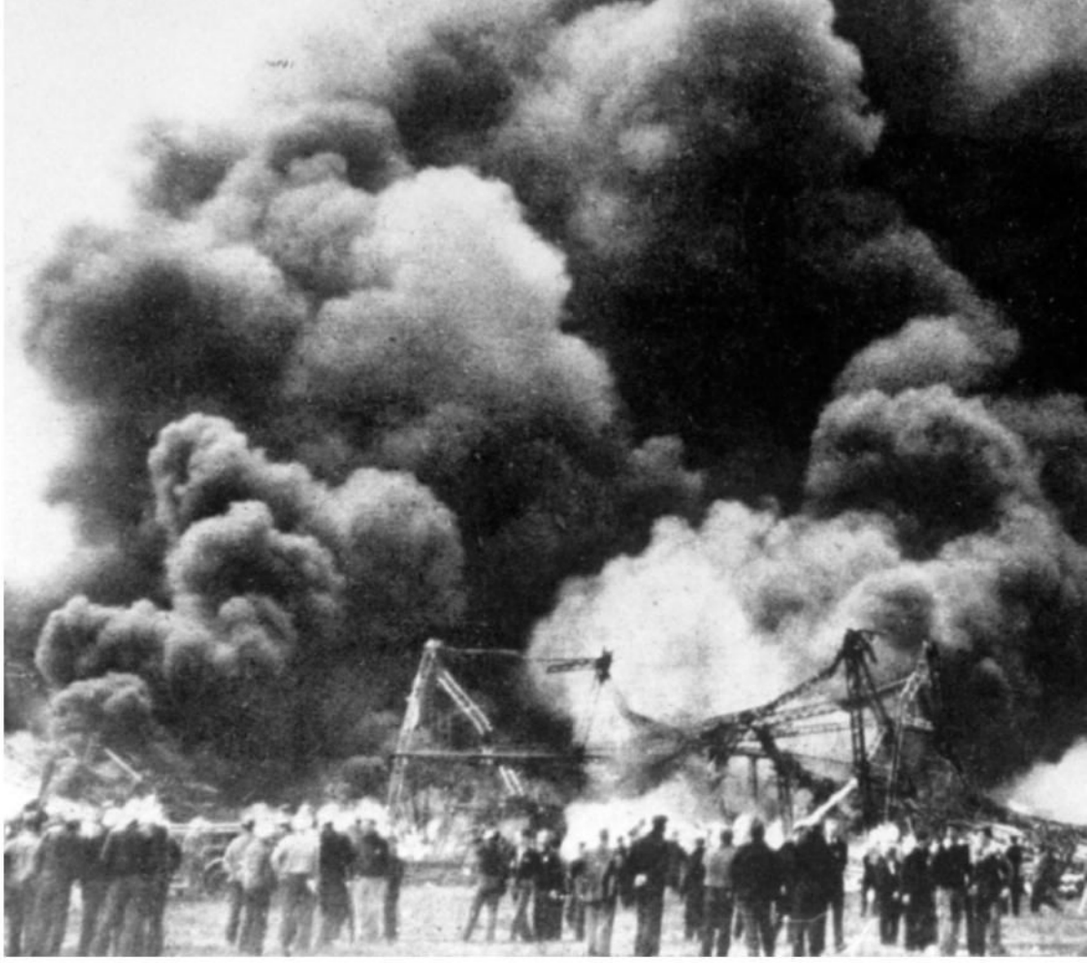
The airship is engulfed by flames

EMBLEM OF NAZI POWER

The Hindenburg was a symbol of Nazi power. The year before its crash, in August 1936, the German Olympics had taken place, showing the world what a powerful and successful nation Germany was. The Hindenburg had been decorated with Olympic rings on its side, and at the opening ceremony, it flew over the Olympic Stadium in Berlin, pulling a large Olympic flag behind it. It cruised for over an hour, while the crowds both in the stadium and Berlin's streets watched. The ship also had swastikas on its tail fin.

A couple of months prior to the Olympics, the Hindenburg and its sister ship *Graf Zeppelin* had taken part in a tour of Germany to raise support for a referendum relating to the remilitarisation of the Rhineland (the referendum received, unsurprisingly, overwhelming support). Patriotic tunes were played loudly from the airships, and loudspeakers on board made announcements, while propaganda leaflets and flags were dropped on the cities below.

In September 1936, 17 aircraft flew over Nuremburg in a swastika formation, followed by the Hindenburg – again a propaganda mission, marking the end of the 8th NSDAP Congress, better known as the Nuremburg Rally. This was the annual National Party Convention of the Nazi party, and a key propaganda event for Hitler and his campaign. The 1936 rally was known as the Rally Of Honour. The official account of the rally recorded that a parade had begun at 8am on the final day – the Day of the Wehrmacht – with a fighter squadron flying low over the field. Behind it came the Hindenburg squadron, followed by four more, the noise of the planes filling the air as the crowds below watched, enthralled. Later, after a speech by Hitler, the Hindenburg again appeared in the sky, and flew low over the Zeppelin field. It was reported at the time that crowds were cheering it on and waving their handkerchiefs in the air in support. To the many civilians spectators, the appearance of this very modern, technologically-advanced form of transport must have seemed like a sign that they were part of a new order that would dominate the world, just as its airship dominated the skies.



"The Hindenburg was the world's largest airship – twice as big as the Graf Zeppelin"

the assistant secretary of commerce in charge of aviation, called rumours of sabotage "irresponsible" before describing the explosion on board as "very, very puzzling".

The rumblings were not flights of fancy. In 1935, a bomb had been found hidden under a chair in the Graf Zeppelin's lounge. A passenger on a previous Hindenburg flight had acted suspiciously, and diagrams of the ship were later found in the man's hotel room – after he had vanished. In 1937, anonymous letters were sent to Dr Eckener, warning that there would be dire consequences if the Hindenburg tried to land at Lakehurst. One woman in Milwaukee sent a letter to the German ambassador to the US, stating that she had information that suggested the Hindenburg would be destroyed by a bomb during its flight. Such threats were taken seriously by the SS and the Deutsche Zeppelin-Reederei – the airline responsible for operating the Hindenburg – and so the day before the Hindenburg was due to leave Frankfurt's airport, SS troops were stationed there with rifles. The ship was also searched, from its stairways to its kitchen. The only area that could not be searched was where the gas cells were located, as they had already been filled with hydrogen. Both crew and troops felt the searches and the sentries were unnecessary – and in fact joked about them. Nothing was found during the searches.

One paper speculated that the disaster was due to one of two factors – either gas had escaped during the descent and ignited, or there were electrical disturbances following a severe storm. Another paper, however, quoted a German atomic physician, Professor Otto Stern, as saying the fire may have been caused by "spontaneous combustion". Yet another, quoting Dr Eckener, who spoke at the official inquiry in Lakehurst, said a spark "from the sky" and a broken brace wire were the probable causes. Yet speculation about a possible conspiracy, or sabotage, continued to be whispered about, even as experts debunked them.

The Hindenburg was the world's largest airship – twice as big as the Graf Zeppelin, which had been on its way from Rio de Janeiro across the Atlantic at the time of the disaster. Steps had been taken to make the Hindenburg as safe as possible – the danger of fire had been reduced by the use of helium gas, its exterior had been treated with aluminium powder to minimise the effect of heat from the sun, and it could travel at least 8,000 miles without needing to refuel. It seems that this was the future of transatlantic travel; a comfortable journey in an airship with a cruising speed of 80mph – the airship being described as being 'as safe as a train'. On an average journey, the Hindenburg could carry nearly 50,000lbs of mail and other cargo, and a total passenger weight of up to 8,000lbs. All steps, it seemed, had been taken to make it as safe and as modern as possible in terms both of technology and comfort. So had the ship fallen victim to an act of anti-Nazi sabotage?

The Hindenburg's skeleton continued to burn after it had crashed to the ground in flames

WEAPON OF WAR

It is perhaps not surprising that the zeppelin airship ended with a scene of destruction at the naval base in Lakehurst, New Jersey, for it had been designed for use in war. The zeppelin was a rigid airship pioneered by Count Ferdinand von Zeppelin at the end of the 19th Century. It was only used commercially for the first time in 1910, but by the start of the First World War, zeppelins had carried over 10,000 passengers on over 1,500 flights.

But it was during the war that the zeppelin came into its own, with the German military using the airships as bombers and scouts, killing over 500 people in British bombing raids alone. Kaiser Wilhelm, despite being related to the British royal family, approved the use of zeppelins in raids on Britain in January 1915, although he only agreed for London to be targeted months later. The Germans finally attacked London on the night of 31st May 1915. The zeppelin's first bomb hit Stoke Newington, before others were dropped on a course heading east through London, creating over 40 fires, and damaging many private houses, as well as religious and public buildings. These raids were fatal; the deaths included those of two sisters, aged three and 11.

A depiction of a burning German zeppelin, being cheered by the French, from 1916

The truth was more prosaic. The Hindenburg may have been the most famous airship disaster – but it was not an isolated incident. Four years earlier, the US naval airship Akron had crashed into the sea off the New Jersey coast, killing 73 people. Then a Blimp airship searching for survivors of the Akron disaster was itself blown into the sea, killing two. In February 1935, the Macon – sister ship of the Akron – fell into the sea off the Californian coast, and lost two more people. Back in 1921, the R38, a British airship, was wrecked over the Humber, killing 44. Britain built another airship, the R101, but in October 1930, it had crashed in France en route for India. 48 people were killed, and the British airship building industry was stopped as a result. Similarly, the US had stopped building airships following the Macon's fate. It was noted that between 1921 and 1923, 132 people had died in airship related deaths – in 1923, the French ship Dixmude was wrecked, killing 54; then, in 1932, US airship Roma was burned at Virginia, with 34 being killed. In 1928, the Italian airship Italia was flying over the North Pole when it was forced down in the Arctic – seven people died.

So there were clearly issues with safety when it came to airship travel. Wind was an obvious peril – as had also been demonstrated with the fin damage that caused argument between Eckener and Lehmann the year before; but the key issue was with the gas used to power the ships. The Hindenburg was filled with hydrogen, which is very flammable – and the potential danger of this was recognised on the airship, which banned passengers from bringing matches or cigarette lighters on board. However, the ship did have a smokers' lounge, where cigars and cigarettes could be bought – but passengers were not allowed to smoke outside this one room, and a stewardess in the room was responsible for ensuring that nobody left it with a lit cigar or cigarette.

Captain Alfred Gilmer Lamplugh of the British Aviation Insurance Company, a former RAF pilot known as 'Lamps', had said, after the disaster, "I had two trips on the airship last summer, and I felt as safe in her as on the ground." But this had a caveat. He had felt that the only risk of an accident would be if the airship collided with something – that "would have been disastrous, because she was filled with hydrogen. The safe gas, helium, was far too scarce and expensive."

It was not just a collision, though, that could cause the hydrogen to ignite. In the 80-odd years since the disaster, many theories have been posited about what caused the explosion, but despite the talk of conspiracy theories, the general consensus today is that the hydrogen that fuelled the Hindenburg was also leaking from it. A spark, from a discharge of atmospheric electricity as the airship made a turn, then ignited the lethal gas, and destroyed not only the Hindenburg, but the future of airship travel. But although it was a portent of doom – the destruction of a key part of Nazi propaganda – Hitler still continued to move inexorably nearer to world war, and a far greater number of deaths.

Dazed and bloodied, but survivors – a male and female passenger pictured shortly after the Hindenburg crash

IN BRIEF

- **Death toll: 774**
- **Worldwide**
- **2002-2003**

At the end of 2002, hundreds of people fell ill with what appeared to be pneumonia. The answer came after one man visited Hong Kong from Guangdong: he inadvertently spread the virus sparked a global health pandemic.

SARS: FIGHTING FOR A CURE

As the virus infected thousands of people across the world, scientists raced to discover exactly what it was

The ninth floor of the Metropole Hotel in Hong Kong looked like any other. Artwork adorned the walls of the lobby, people came and went to their rooms, there were nods of acknowledgment among tourists and businessmen but very little engagement beyond that. Professor Liu Jianlun was in the city for a wedding and he was among the many guests staying on that floor. But he was ill, coughing and sneezing, feeling short of breath and high in temperature and he felt so bad that he did not attend that wedding. Instead, he visited the Kwong Wah hospital and told medical staff: "Lock me up. Don't touch me. I have contracted a very virulent disease." Just over two weeks later, he was dead.

His brief time in the hotel had been notable. The 64-year-old had checked in on 21st February 2003 and he had stayed – rather ironically – in Room 911. He'd walked down the corridor, shared a lift and, as investigators suggested, he'd been sick on the carpet outside his room. But in the course of his walkabouts, he had unknowingly passed on his virus to at least 16 other guests on that floor. One of them was Kwan Sui-Chu who had travelled from Canada to Hong Kong to visit her son. On her return to Toronto, she fell ill and died. Her son, Tse Chi Kwai, died too, as did the patient in the bed next to him in hospital. But that was just the start.

American businessman Johnny Chen, aged 48, had flown back to Vietnam after coming into contact with the professor and, suffering much the same symptoms, he went to hospital in Hanoi five days later. There he was treated by medical staff including the World Health Organisation expert in communicable diseases, Dr Carlo Urbani, before being transferred to a hospital in Hong Kong for specialist treatment. It was in vain. Chen died on 13th March but the virus also claimed the lives of Urbani and two other staff. And so it went on. People who had been infected by Liu were leaving Hong Kong and spreading it to family, friends and strangers in their own countries. The world suddenly had a health pandemic on their hands.

Liu had been a respiratory diseases expert working in the neighbouring Chinese province of Guangdong. He had been working in a hospital in Guangzhou looking after patients who displayed identical symptoms to his own and he saw the progression of their illness and the speed at which it took hold and laid them to rest. The victims were being hooked up to artificial ventilation and placed in intensive care in a bid to keep them alive. By the time Liu had fallen ill, the government of Guangdong admitted 305 people had contracted atypical pneumonia since 16th November and that five had died. No-one had an inclination then but the illness was to become known as SARS – or severe acute respiratory syndrome. It would dominate the health agenda for months.

Professor Malik Peiris was watching the developments with great interest. He had been studying avian flu since 1997 and he had already cancelled his Christmas holiday of 2002 in order to look at two unusual outbreaks of the H1N1 influenza virus. The problem in China, which was being widely reported in mid-February of 2003, was pointing to a potential human transmission of avian flu and he was keen to take a closer look. "It was an unusual pneumonia that was causing severe disease and outbreaks in hospitals," he tells us. "We were worried that avian flu was causing problems in humans and we decided to take a closer look."

The illness was seen to be clearly attacking the lungs and affecting the deep lung tissue. "Essentially, patients were unable to breathe and they would run out of oxygen," Peiris says. "The body's response to SARS was also making the lung damage worse – there was a battle going on in the lung and the human reaction was contributing to the problem which was an unusual pattern but one that you see in avian flu."

Initial investigations had already ruled out a number of possibilities. It wasn't anthrax or leptospirosis, nor haemorrhagic fever or pulmonary plague. Worried that it may actually be avian flu, the World Health Organisation had sought permission to send an investigative team but when they arrived in Beijing on 23rd February, they were not granted access to visit Guangdong - much to the frustration of the fact-finding mission. Instead, the Chinese Ministry of Health made its own claims, later saying the problem in the province was most likely chlamydia pneumoniae. As it turned out, it wasn't that at all.

By now, dozens of people were falling ill in Hong Kong and elsewhere, and on 12th March, a global alert was issued. SARS was traveling faster and wider than any other outbreak ever seen and it was claiming many lives in the process. Some people said it showed the inherent risk of a globalised world and experts claimed no country could be deemed to be safe. But they were right to look on the dark side in this instance since every government was viewing the situation with trepidation, hoping the virus wouldn't land within their borders.

In the UK, the Secretary of State for Health was speaking of the need for public health surveillance and of managing patients to reduce the risk of cross-infection. There were guidelines for travelling to Southeast Asia and governments were cancelling flights and businesses, while schools were shutting their doors as worry about the illness spreading became more and more acute. Cases were being reported in Spain, Germany, Slovenia, the US and the UK, and plans for containment were formulated. "There were reports of SARS in Vietnam and alerts in Singapore and Canada," Peiris adds. The world was on edge.

Under such circumstances, it was perhaps only human nature to play the blame game to a degree. Fingers began to point towards the slow response of the Chinese authorities and there were accusations that the country's attempts to hide the significance of the disease had caused SARS to spread far wider than it should have.

"Fingers began to point towards the slow response of the Chinese authorities"

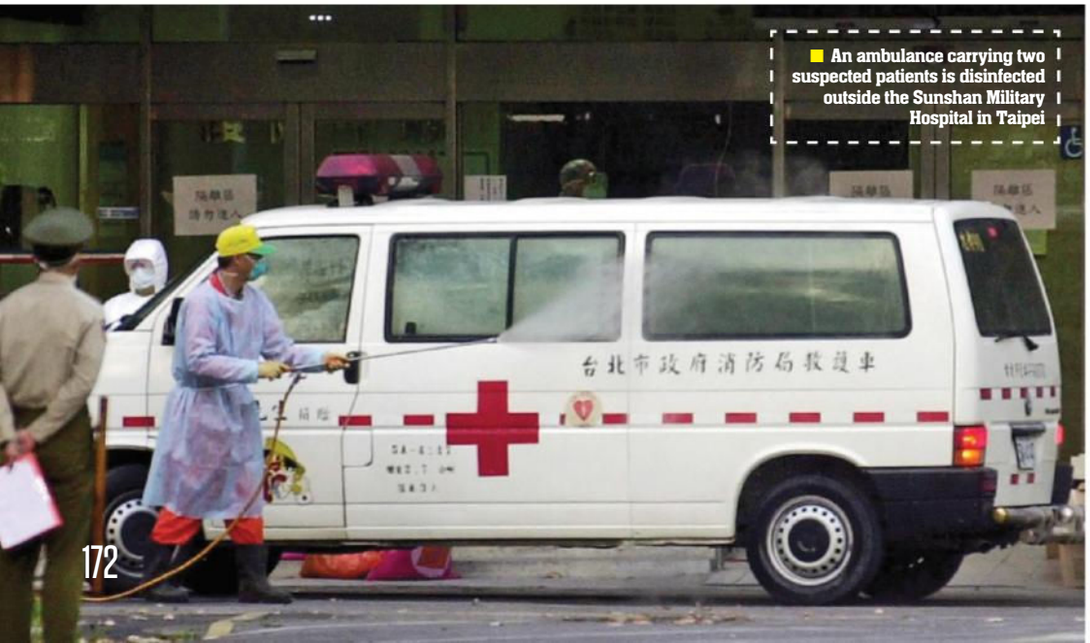
The accusers had a point, though. Beijing only officially acknowledged SARS was present in China on 26th March and even then it said it was due to a handful of "imported" cases. Finally realising its error, the country apologised for its slow response on 5th April.

"Looking back, we now know there were cases of SARS in 2002 and it had spread within Guangdong," Peiris says. "If the virus had been identified at that time, then we could have worked on it before it ever got to Hong Kong and to the rest of the world. But instead, it spread within the hotel here and within days those patients had gone back to their various countries. On that day there was no chance for us to prevent it: the patient [who was initially infected] was not even in hospital. But the chance of an earlier response would have likely reduced the spread so much more."

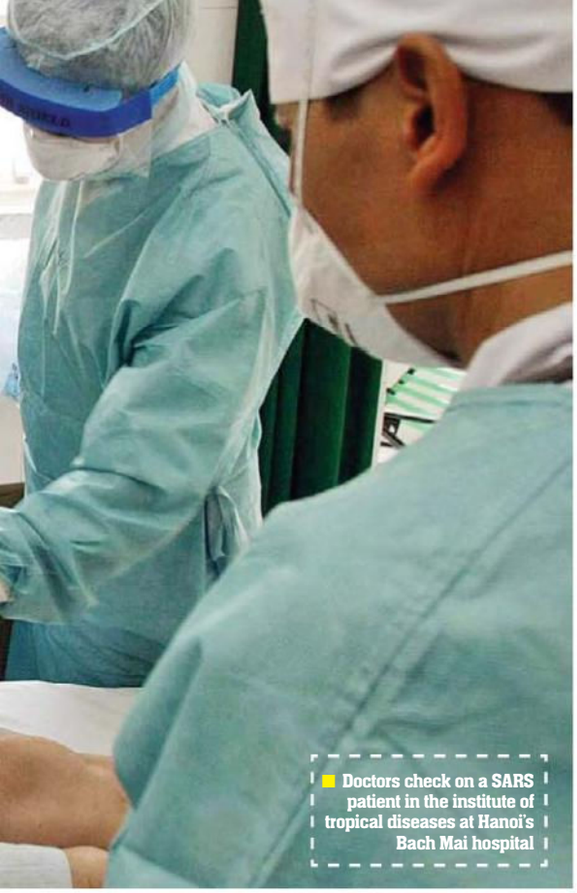
Even so, Peiris and his team threw themselves into the task at hand: to find the virus that was causing the disease. "The hospital authority in Hong Kong was heightening its surveillance of all significant pneumonia cases and we were investigating them to see if anything unusual was going on," he says. "We monitored those who were coming from Guangdong because there is a lot of movement between the province and Hong Kong and we were able to exclude avian influenza and all other known respiratory viruses and bacteria. It was only then that we knew we were looking for something new."

The Chinese University of Hong Kong together with counterparts in Canada, Germany and Singapore initially believed the virus was a paramyxovirus which could have put it in the same bracket as the cause of measles, mumps and respiratory tract infections, but that was soon found not to be the case. The WHO, meanwhile, believed it to be a novel pathogen. And then, on 21st March, there was a breakthrough. Peiris, who said his team had been growing some unusual viruses from two patients, emailed the WHO laboratory network. His team, he claimed, had isolated the SARS virus.

"Basically, we were growing this virus in a subculture and then simultaneously we were trying to do a number of things with it," Peiris explains. "We were asking, are there normal cells, a virus or something else? We made sections of the infected cells and put them under a microscope and we could clearly see the virus particles, although that didn't identify exactly what the virus was.



An ambulance carrying two suspected patients is disinfected outside the Sunshan Military Hospital in Taipei



Doctors check on a SARS patient in the institute of tropical diseases at Hanoi's Bach Mai hospital

We tested it on the blood samples of a number of patients who had suspected SARS. Our hypothesis was that, if the virus that we had in our hands was a pointer to the disease, then patients should be making a committed response to the virus. Lo and behold, that was the case."

The blood samples were reacting against the virus and behaving in a way that led Peiris to believe he was on the right track. "The eight people whose blood samples we had were becoming antibody positive to this new virus and reacting to it. But as other patients previously were negative, it suggested it was a new virus. We looked at it with a different type of technique under the microscope and we saw the characteristic spikes and signs of a coronavirus. My colleague was able to fish out small fragments of nucleic acid from the virus and after sequencing it helped to confirm that it was a unique coronavirus and that is how the whole picture came together."

As well as identifying the virus, Peiris and his team began to devise a basic medical diagnostic test that would allow signs of the illness to be spotted far more quickly than before. This would be crucial in aiding the identification of infected patients and helping to prevent the spread of the virus. Some scientists were aware that Liu had died because the hospital in Hong Kong had never come across SARS before. Both they and the WHO understood that education and discovering methods of diagnosis allowed medics to fight back.

"I think we knew the virus would be transmitted by sneezing and coughing when we saw patients in Guangdong coming in and transmitting to patients and doctors in the ward. But we needed a diagnostic test," Peiris says. "The big problem is that severe pneumonia is a common condition even now. You can go to intensive care units anywhere in the world and there will be patients with severe pneumonia. Some will unfortunately

THEY DIED AS HEROES

Dr Carlo Urbani, a World Health Organisation worker based in Hanoi, Vietnam, was adamant: "If I don't go now what am I doing here? Just answering emails and going to cocktail parties? I'm a doctor. I have to help."

His wife was understandably worried that his job would put him in grave danger and when he got the call from a local hospital asking him to visit the businessman Johnny Chen who was severely ill with SARS, she hoped he would not go.

But he insisted that he had to help even though the risk of exposure was all too great. In that, he was typical of so many health professionals all around the world, and yet Urbani's wife was right: many of them – including her husband – died in the course of their duty.

Although 150 doctors and nurses in Taiwan left their jobs out of fear in a single week in May 2003, they were actually shown to be the exception. The majority of doctors and nurses overwhelmingly wanted to assist and even when hospital managers hoped to persuade medical staff with young families to stay away, very few of them did.

Not that the medics didn't think hard about their own families. On the contrary. In taking up those roles, many of the medical staff did not dare go home in case they inadvertently infected their loved ones with the deadly disease.

It effectively meant they were on a round-the-clock programme of care and it left a mark on each one of them, a mix of sadness and pride. Yet if it wasn't for their diligence and expertise, the death toll would have likely been much higher and the spread of SARS far worse. They were the heroes of 2003.

A security guard checks the temperature of a driver as part of efforts to combat SARS.

THE LASTING EFFECTS

As you can imagine, going back to normal in Hong Kong after such a major health scare wasn't easy. For a start, there were political repercussions – Hong Kong's Health Secretary Dr Yeoh Eng-kiong resigned having been accused in a report of issuing misleading public statements about SARS in July 2004 – and there was an economic downturn that affected the lives of many too.

But eventually, Hong Kong not only picked up, it began to flourish once more. Key buildings including Amoy Gardens were overhauled (in this case to the tune of $7.7 million) and while the BBC reported that residents of those blocks felt stigmatised by the news coverage, property prices boomed, making it a sweeter pill to swallow. Indeed, today, Hong Kong is one of the world's most expensive cities in which to live and, for most, SARS is a distant memory.

Not that there aren't any reminders. Visit the hotel at the epicentre of the outbreak and you'll struggle to find room 911. A year after the outbreak, the Metropole Hotel bosses whipped the number away from the door and replaced it with 913. The hotel then went on to bizarrely insist that the room was always named 913 in what can only be explained as a reluctance to turn it into a ghoulish tourist attraction.

succumb and some will recover. But the fact is, in a number of cases, no clear bacterial virus is identified. We just know how to treat these patients. With SARS, there was no simple way to distinguish patients infected with the normal bugs that cause pneumonia and this new disease. Having the virus and sequence in hand, we were able to develop the diagnostic tests within days. We had concrete proof to detect these cases and that was fundamentally important."

The doctors also made an important observation at this point. When someone contracted SARS, there was actually a window of opportunity for treatment, since it was discovered that patients were far less infectious at the start of their illness than they were after two or three days. "It gave us a time window for getting people into hospital and this enabled us to break the transmission in the community," explains Peiris, whose findings were confirmed on 27th March.

In order to halt the spread of the disease, a programme of isolation was put in place. An entire 35-storey block of Amoy Garden in Hong Kong, for instance, was ordered to remain inside for ten days before being moved to the country for a further ten days. "There was a freak incident where one patient was sick and he did not know that he had SARS," Peiris explains.

"His clinical presentation was rather atypical and he had more diarrhea than pneumonia. He visited a relation in a densely-populated housing estate in Hong Kong and infected almost 300 people but this was a completely unique event. There had been no single transmission between one person to such a large number. But, of course, in four or five days, Hong Kong had 300 new patients with SARS and it overloaded the system. There were not enough isolation beds available for such a large number and it posed problems."

There were continued attempts to isolate the whole of Hong Kong and Guangdong too. Seen as the hub of the virus, travellers were warned away unless it was essential that they visit, but still the virus spread, reaching Africa on 9th April. By this time, more than 1,300 people were infected and 82 were dead. Attentions began to turn towards the true source of the virus, and rumours that animals or pets could carry the disease were leading to man's best friends becoming enemy number one.

There was speculation that the Amoy Gardens infection had been caused by rats or cockroaches that had resulted from an inadequate arrangement of the bathroom drains. But a report that a cat had been the source of SARS led to much greater panic: people were taking to the streets to dump their pets – including dogs, rabbits and hamsters – by the roadside. The Society for the Prevention of Cruelty to Animals in Hong Kong subsequently reported a large increase in abandoned animals. Yet the truth about where SARS had initially come from was somewhat different.

Yuen Kwok-Yung, a microbiologist at the University of Home Kong, had identified the masked palm civet – a cat-like mammal which

"People were taking to the streets to dump their pets – including dogs, rabbits and hamsters – by the roadside"

KEY MONTHS OF SARS

FEBRUARY 2003

This month, the world began to wake up to SARS although it didn't quite know what the illness was at this stage. An atypical pneumonia had been reported in China and the first known case of SARS was discovered to have dated back to November 2002. But the WHO was becoming frustrated in its attempts to draw more information from the Chinese Ministry of Health. Worse, as China later reported 305 cases of an unknown respiratory syndrome that had killed five, Dr Liu Jianlun visited a Hong Kong hotel on a trip from Guangdong.

MARCH 2003

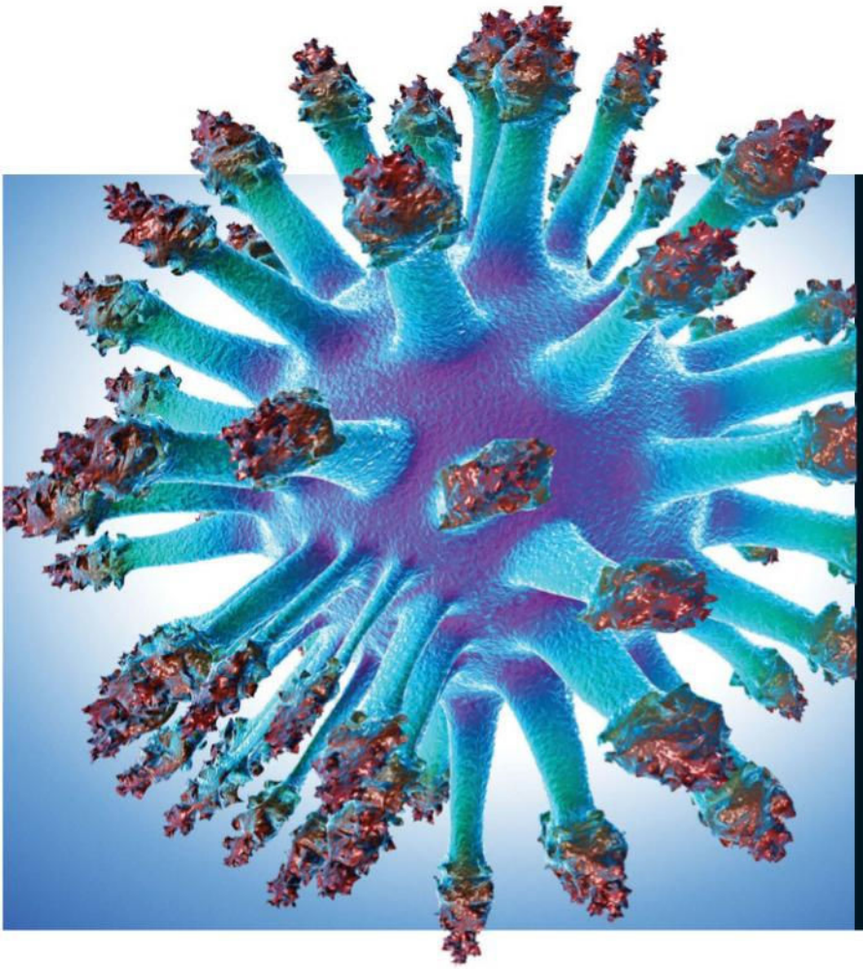
Liu's visit had infected 16 people who returned home to various countries, spreading the virus in turn. Vietnam-based Dr Carlo Urbani treated Johnny Chen and he expressed alarm at SARS' rapid spread. Efforts to discover what it were stepped up throughout March: indeed, 11 laboratories in nine countries worked on unlocking the virus in a 'race' won by Malik Peiris from the University of Hong Kong. Beijing received its first case and 18 healthcare workers reported falling ill at the Prince of Wales Hospital in Hong Kong. The situation was worsening.

APRIL 2003

Finally recognised as a coronavirus, the WHO placed stringent travel advice on Hong Kong and Guangdong provinces in a bid to control SARS' spread. Later, Canadian researchers successfully sequenced the SARS' genome and the WHO announced that a new pathogen member of the coronavirus family was the cause of SARS. Scientists tested it on monkeys and found it to cause similar symptoms. But the identification allowed for better medical planning. Meanwhile, Beijing admitted the situation was worse than it had reported.

MAY 2003

Scientists continued to uncover new details about the virus, including its ability to survive in faeces for more than 48 hours and in urine for a day. It put medical staff on alert but the extra information helped in the battle to prevent further contamination. It became accepted that more than half of all deaths from SARS would affect those aged over 45. By the end of the month, restrictions on travel eased and the situation was deemed to be under control. Singapore was declared free of SARS by 31st May and others quickly followed suit.



SYMPTOMS OF SARS

SARS is a viral respiratory disease caused by a member of the coronavirus family. To complicate matters, various symptoms may or may not be present and many of them are flu-like in nature. They can include a fever, headache, muscle aching, chills and shaking. Some people may feel dizzy or suffer the pain of diarrhea while less common are sore throats, a runny nose, nausea and vomiting. But in every case, SARS sends a patient's temperature beyond 38 degrees Celsius and it also typically causes breathing difficulties and a cough. These are the tell-tale signs many doctors watched out for in 2003.

The virus was passed between humans through infected droplets of nasal and mouth spray expelled from the body in sneezes and coughs. It was found that the virus could survive outside the body for up to six hours and that it could be transferred hand-to-hand and also through the air. But the symptoms did not surface immediately after contact: it would take at least a couple of days and sometimes up to a week-and-a-half for the first signs of the illness to be felt.

At its worst – and certainly if it is left untreated either via mechanical ventilation, oxygen or antipyretics – SARS can be a killer. It can lead to viral pneumonia or secondary bacterial pneumonia and the breathlessness can become so acute that it suffocates the patient. There is no simple cure either – no-one has come up with a vaccine.

For that reason, during the outbreak, advice centered on prevention. To help prevent SARS developing, people were advised to wear a surgical mask, avoid bodily fluid contact and more. Treatment primarily involved the isolation and quarantine of patients but it was effective in eventually preventing its long-term spread. The good news is that, despite SARS being a very serious disease, more than 90 per cent of people survived and it was a relatively rare virus even during the short spell in which it became a global concern.

is treated as a delicacy in parts of China – as the potential culprit. Four of them were found to be carrying the coronavirus that caused SARS and it led to questioning over whether the virus may have jumped across to humans. As the news began to be reported, Peiris told journalists that the virus would be killed if the meat was properly cooked. But, as he later discovered, the truth was even more complex than that.

"In China, there are wild animals of diverse types which are eaten because they are believed to heal the body," he says, pointing to civets being among them. "The prediction was that the animals that were being sold on the markets in Guangdong could have carried the SARS virus and my colleagues who sampled the civet cats had found just that.

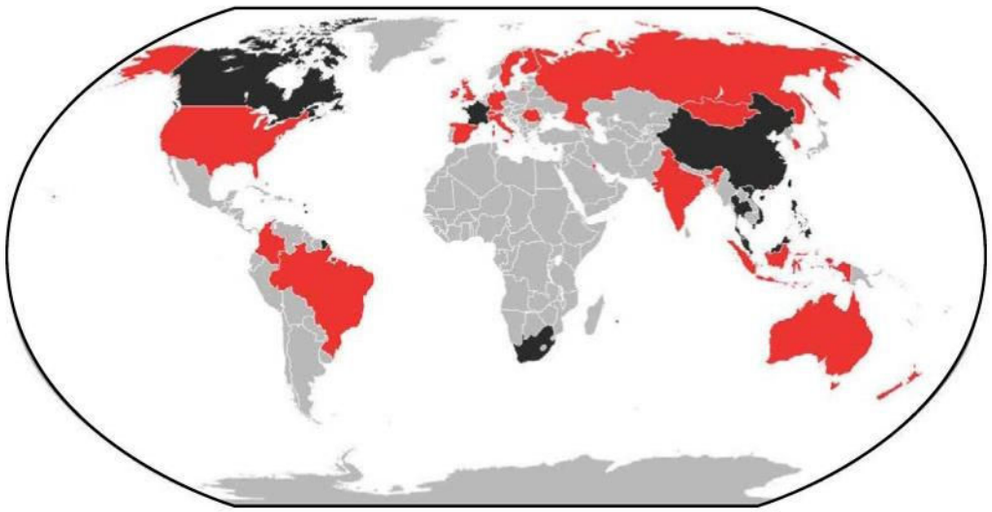
"But further studies showed that the civet cats on the market showed signs of having the SARS virus but those in the wild did not. So the thought was that it was coming from somewhere else. It soon became clear that the virus was actually coming from the bats that were also sold in the markets: the virus was presenting in the tiniest horseshoe bats and it seemed that it jumped to other animal species. That wasn't difficult – the animal market in Guangdong is bigger than most zoos and it became a reservoir for the virus.

"Now we knew how SARS jumped to humans, we could also see how it changed over months to the point where it could be passed from human to human. And that is how it emerged." This knowledge would be crucial in enabling the authorities to look at ways to prevent a reoccurrence. Officials in Guangdong in 2004, for example, ordered the immediate killing of every captive civet cat.

But it was the policy of containment that truly allowed the authorities to fight back. Their key weapon became the thermometer, which allowed doctors to identify people with critical temperatures and get them into quarantine where they could be treated. This swift ability to recognise SARS and help victims meant that, by June, the World Health Organisation was lifting its warning against travel in four Chinese provinces and Taiwan. On 24th June it also removed Beijing, something Shigeru Omi, the WHO regional director for the Western Pacific, called a "milestone in the fight against SARS, not only in China but in the world". One by one, countries and cities were being declared SARS free: from Singapore to China to Hong Kong to Taiwan.

For Peiris, his fellow scientists and the World Health Organisation, it was a triumph worth celebrating. "The outbreak was contained and that was a major public health success for the global community," he says. "It was extremely important and it worked by coordinating information between different countries. By July the outbreak was essentially contained and over."

And so it was. Although there were isolated cases after July, SARS had largely been controlled and eradicated. People could finally breathe a sigh of relief, although the statistics were nevertheless depressing. In total, SARS affected 8,096 people in 30 countries and claimed 744 lives.



The areas of the map marked black showed the countries with confirmed deaths while red shows confirmed infections

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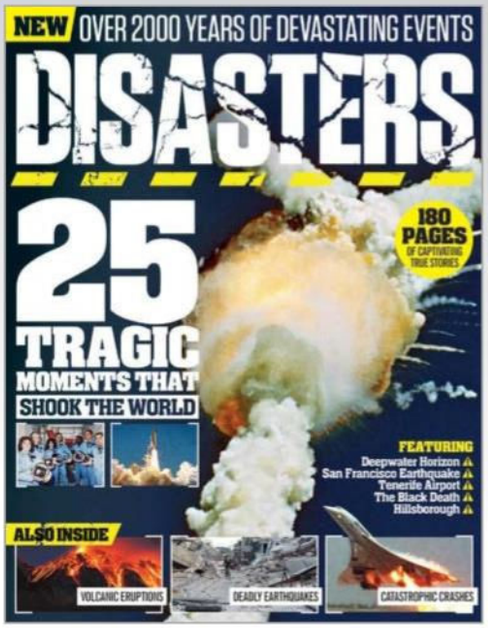

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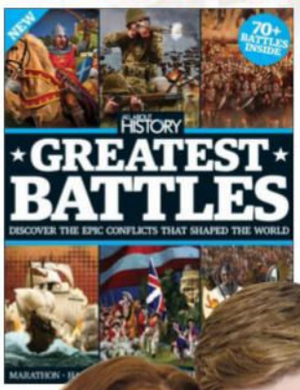

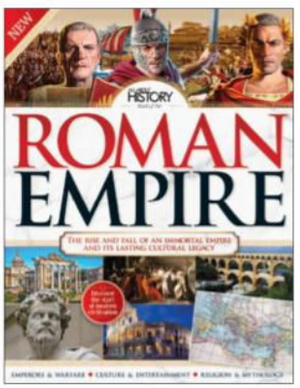

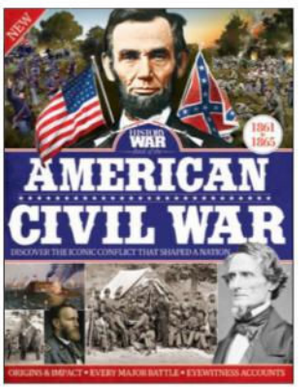

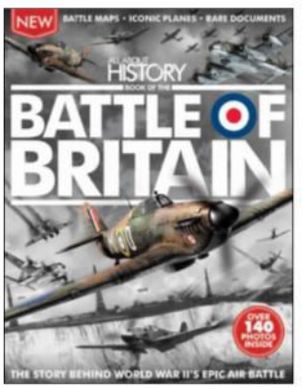

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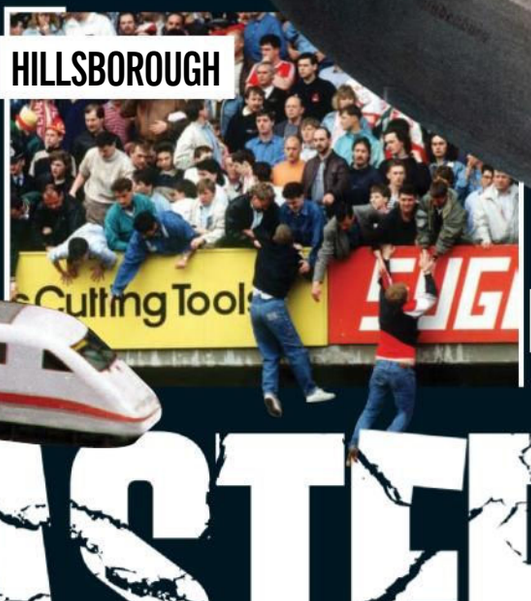

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